VOL VII

NO. 4

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

S·A·E

OCTOBER 1920

SOCIETY OF AUTOMOTIVE ENGINEERS Inc
29 WEST 39TH STREET NEW YORK

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Vol. VII October, 1920 No. 4

Fuel Production Statistics

THE fear that has been prevalent that fuel production for internal-combustion engines would not be adequate has been much allayed for the time being at least. The address of General Secretary Welch of the American Petroleum Institute, presented at the session conducted by the Society at the annual convention of the National Gas Engine Association in Chicago last month, was illuminating and reassuring. He expressed the view that over 500,000,000 bbl. of crude petroleum would be produced in and imported into the United States during this year. He called attention to the great well-drilling campaign that has been inaugurated recently with telling and gratifying effect. He gave various sidelights by way of illustration of the economics and psychology of the oil business. Mr. Welch's remarks are printed elsewhere in this issue of the THE JOURNAL.

The production of gasoline in the first six months of this year is approximately 13 per cent larger than during the first six months of 1919. There were 307 refineries operating at 73 per cent of their rated capacity in June. The domestic consumption of gasoline in the first half of 1920 was 28 per cent greater than during the same period of 1919, while the total consumption of gasoline was approximately 32 per cent more. The table on page 312 illustrates in balance-sheet form the relation of the actual production and consumption figures for the first six months of the years 1919 and 1920. It will be noted that the production of kerosene has increased 8 per cent, while the consumption, both domestic and foreign, has decreased 11 per cent. This condition is reflected in the increase of 67 per cent in the kerosene stocks over those of June 1919.

The seasonal demand for gasoline is well illustrated in the accompanying chart of production and stocks. Stocks represent the reserve supply and the difference between stocks at the beginning and end of each month plus the production for the month represents the apparent consumption. As consumption is lowest in the winter season, stocks build up usually from October to June of the following year. From June to October they decline, since during this period consumption exceeds production, the shortage being made up by drawing on stocks. Although stocks reached a higher total in 1920, the seasonal decline began in May, two months earlier than in 1919. At

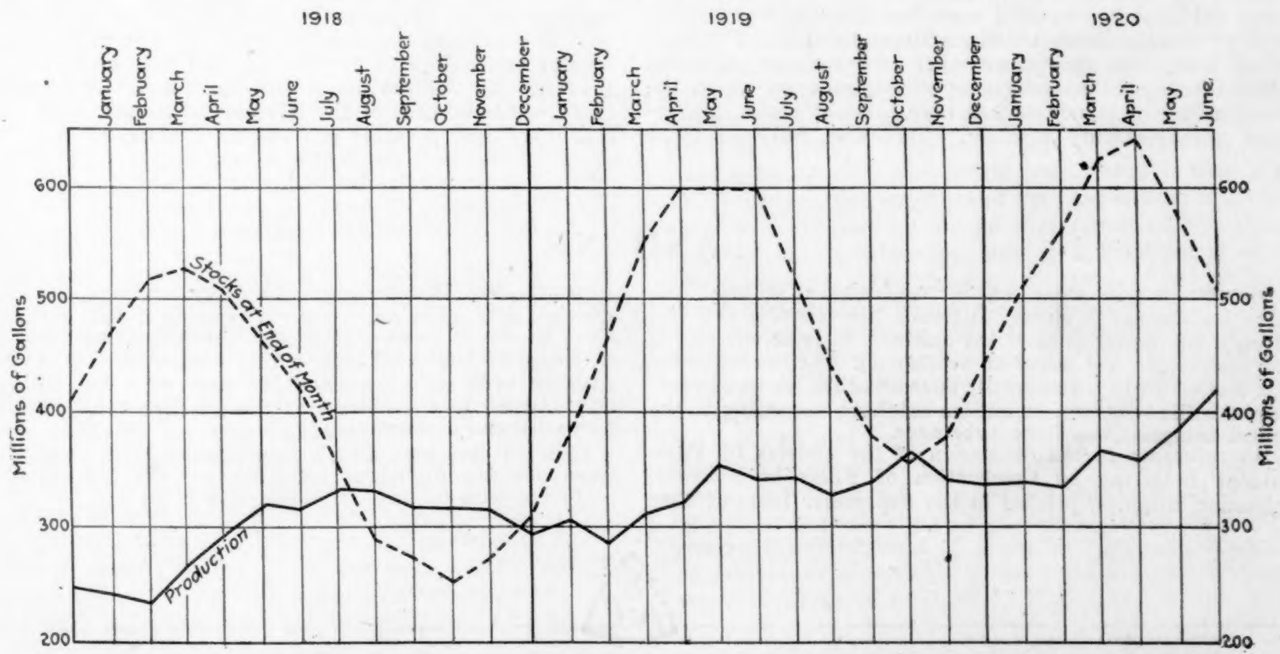


CHART SHOWING THE RELATION THE PRODUCTION OF GASOLINE AND THE STOCK ON HAND BY MONTHS SINCE JAN. 1, 1918

COMPARATIVE ANALYSIS OF PRODUCTION AND CONSUMPTION

	Gasoline		Kerosene	
INCOME	1920	1919	1920	1919
Stocks, Jan. 1, gal.	446,793,431	297,326,983	339,319,690	380,117,829
Production, Jan. 1 to June 30, gal.	2,178,281,185	1,911,152,705	1,120,517,007	1,045,746,955
Imports, gal.	21,686,348	6,782,925	....	....
TOTAL, gal.	2,646,760,964	2,215,262,613	1,459,836,697	1,425,864,784
OUTGO				
Exports, gal.	286,657,962	177,798,652	419,111,094	475,290,524
Shipments to insular possessions, gal.	10,270,476	9,727,264	6,317,905	10,122,293
Domestic consumption, gal.	1,845,776,925	1,433,840,087	613,064,345	687,909,533
Stocks, June 30, gal.	504,055,601	593,896,610	421,343,353	252,542,434
TOTAL, gal.	2,646,760,964	2,215,262,613	1,459,836,697	1,425,864,784

the end of June, stocks were 15 per cent less than at the same period in 1919.

The Bureau of Mines states that the production of lubricating oils increased 22 per cent during the first half of this year, while the stocks were lowered due to an increased consumption of 35 per cent. The export of lubricating oils was very great as compared with other petroleum products, representing 41 per cent of their total consumption during the first half of 1920. The increasing use of oil as fuel in ocean vessels is shown by the consumption of 100 per cent more bunker oil in the first six months of 1920 than in the same period of 1919.

NATIONAL GAS ENGINE ASSOCIATION MEETING

THE thirteenth annual convention of the National Gas Engine Association was held at the Hotel Congress, Chicago, Sept. 1 to 3. On the opening day at 10 a. m. a professional session included an address by L. M. Ward, president of the Association, and a paper on Power Farming and the Cost of Living, by James M. Irvine. Division meetings were held simultaneously in the afternoon. In the evening a confetti carnival and informal dance offered the members an opportunity for becoming better acquainted and at the same time provided entertainment for all in attendance.

The professional session on the afternoon of Sept. 2 was conducted by the Society, with L. S. Keilholtz presiding. Among the papers presented were two dealing with related phases of standardization. The address by Coker F. Clarkson, secretary and general manager of the Society, on this subject, discussed the underlying principles upon which the superstructure of standards has been brought about in automotive manufacturing practice. This was followed by a paper on the organization of the S. A. E. Standards Committee, by R. S. Burnett, Standards Department manager of the Society, treating in detail the processes involved in bringing about standardization acceptable to the industries affected. William F. Parish discussed the possibilities of simplifying the demands placed upon producers of lubricants. Interesting suggestions were advanced as to means whereby lubricating oil specifications could be adopted and put into effect generally. R. L. Welch, secretary of the American Petroleum Institute, discussed the petroleum fuel supply, prices and demand. An extended discussion followed.

The mornings of the days of the meeting were devoted to sessions at which matters of particular interest to the members of the National Gas Engine Association were taken up. The banquet was held on Sept. 2. The convention was helpful and enjoyable throughout, and indicated clearly the progress the Association is making as an organization in effective furtherance of the interests of its members and the stationary and portable gas engine industry.

ANILINE

IN connection with some popular confusion as to what aniline is, Thomas Midgley, Jr., calls attention to the fact that only one material is called aniline. It is an oil and is often sold under the name of aniline oil. Aniline is never a salt and still called aniline; it may be called aniline hydrochloride, aniline powder, or aniline sulphate, according to the chemical composition of the substance.

With reference to the discussion of the address by Past-President Kettering on Combustion of Fuels in Internal-Combustion Engines, printed in the September issue of THE JOURNAL, Mr. Midgley states that aniline does not go into solution with gasoline by merely pouring it into a tank. It must be either warmed with the gasoline or agitated for a considerable length of time, which cannot be done inside the gasoline tank of an automobile; otherwise the aniline oil will "settle" to the bottom of the gasoline tank, and interfere with the carbureter adjustment.

Xylidine goes immediately into solution with gasoline, and there are not attendant upon its use the difficulties that there are with aniline. Xylidine also is an oil.

Development of Oil Specifications[1]

By William F. Parish[2]

FIVE years ago a prominent builder of Diesel engines, in an attempt to standardize the lubricating oil for his new type of 500-hp. engine, sent to 12 of the most prominent oil producers in the country a full description of the engine with photographs and drawings, and asked them to submit a gallon sample of the oil they would recommend for lubricating the engine. The result was that the best oil men in the country submitted 37 different oils, no two alike, varying all the way from 136 sec. Saybolt universal viscosity at 100 deg. fahr. and 41 sec. Saybolt viscosity at 210 deg. fahr. to about 4500 sec. Saybolt viscosity at 100 deg. fahr., which is actually 178 sec. Saybolt viscosity at 210 deg. fahr. For the conditions under which it was to operate, the engine referred to required an oil having a viscosity of from 450 sec. at 100 deg. fahr. for the paraffine oils to 750 sec. at 100 deg. fahr. for the asphaltic-base oils.

In October, 1917, at 15 Government flying fields, with one type of engine practically established as standard training equipment and with every opportunity offered to study conditions, the oil industry represented by 12 manufacturers was recommending and selling 22 different oils for use on these engines; and the viscosity varied from 54 sec. Saybolt universal viscosity at 212 deg. fahr. for the thinnest oil, to 159 sec. at 212 deg. fahr. for the heaviest oil. This type of engine, with several others introduced about the same time, really required an oil having a viscosity of from 70 to 75 sec. at 212 deg. fahr. for the asphaltic-base oils and 85 to 90 sec. at 212 deg. fahr. for the paraffine oils.

The questions for engine builders to consider are

(1) Why is there such a wide difference of opinion among oil men as to what is necessary to lubricate the same machine properly?

(2) Is this difference of opinion worth further consideration, or is oil simply oil, irrespective of the readings given on standard instruments?

(3) Is anything to be gained by having the lubricants properly specified, manufactured and used, for various types of machines?

(4) What system can be introduced that will make it possible for the engine builder, the oil industry and the users of the machines, to cooperate for the purpose of bringing about the desired results?

Regarding question No. 1, lubrication is both an art and a science. Values are established on the basis of experience. The experience of all men, even in the same line of endeavor, varies and the interpretation by several men of the same general facts will not be the same. Therefore, when it comes to the lubrication of a new machine, probably as many different opinions will be given as there are men consulted. Each man will divide the proposition into its several parts and will give undue importance to the items with which he is most familiar. One man will judge the machine on the basis of the circulating system with its filters and pumps and will specify a thin oil that will probably work well with water. Another man will think that the cylinders are the most important and will make that item the basis for his opinion that a thick oil is necessary. In the case of the Diesel engine, the air compressor will seem to some to be the important point, and the experience with that one item, which has not yet been standardized after many years of operation, will amply justify applying almost the entire line of oils on the list.

In reference to question No. 2, the difference in opinion as to the proper lubricant for a certain unit may have a vast effect upon the operation and results obtained from that unit. Taking the Diesel-engine example as an instance, using the lightest oil submitted would permit the main bearings to operate at a low temperature and would give a low power consumption. The oil, however, would be entirely too thin for the power or air-compressor cylinders, and there would be the consequent danger of excessive scoring or wear. On the other hand, it would be impossible to use the heaviest oil recommended in the lubricating system of the engine. Further, this oil would be entirely too heavy for the power cylinders, would form excessive carbon which would prevent the free movement of the rings, would cause scoring of the cylinders and wear, and the same general condition would also prevail in the air-compressor cylinders. This very heavy oil, therefore, would be absolutely unsuited as a lubricant for any part of the engine in question.

Using aeronautic engines as an example to answer question No. 3, from the most careful observations in regard to the lubrication of these engines, it was found that oils which were too thin were consumed so rapidly that forced landings were at times necessary because the supply of oil gave out. A forced landing frequently results in accidents unless there is a landing field available. Conversely, oils that were too heavy caused trouble due to the large amount of carbon formed, and due also to the sluggish feed in starting. The record showed that the larger engines, under certain conditions, would have scored cylinders with these heavy oils and bearings would burn out, troubles that did not occur when an oil of the proper body was used. It seems clear, therefore, that there is a range of viscosity beyond which it is not advisable to go and, that being true, there is also a point where the oil, the engine and the fuel will be exactly balanced. So it may be stated that aeronautic engines, as a class, require lubricants having a fixed range of body, which must be determined by the type of engine and the conditions under which it must operate.

Concerning question No. 4, theoretically the engine builder should be able to specify the classification and grade of oil that should be used on his machine; he should pass this information on to the operator who purchases his machine and the latter should be able to purchase that particular kind of oil wherever most convenient. This preconceives a universal language in regard to oil that would be perfectly understood; and it also makes necessary the general establishment of some form of specification and nomenclature acceptable to both the oil industry and the manufacturers of engines.

History of Oil Specifications

Oil refiners have always been averse to specifications and the attempts made at the standardization of petro-

[1] Paper presented at the S. A. E. Session of the annual convention of the National Gas Engine Association, Chicago, Sept. 2, 1920.

[2] M. S. A. E.—Technical director, lubricating department, Sinclair Refining Co., Chicago.

leum products. This position is easily explained. Specifications or laboratory readings as originally drawn by the refiners were developed for the purpose of allowing the standardization of their own production. The necessary instruments were patented and built by the large refiners for their own use and were not obtainable by the small refiners. Several different methods of taking apparently the same reading resulted. This was especially true of the viscosimeter. The type which is today generally in use was developed by one of the large refiners and for many years could not be purchased or made by the smaller refiners. Many consumers of large quantities of lubricating oil made their own pipettes and other instruments which were not used by the refiners and, while the term viscosity has been used for many years, its meaning in definite terms has been obscure. This is due to the fact that it was often impossible to tell upon what instrument the test had been made, the temperatures used were not always the same and the method of operation was different. As a result of this disorganization, the term conveyed little outside its interpretation by the individual oil companies. Probably the first outside agencies to make use of refinery instruments, when it was found necessary to limit the volatile nature of burning oils, were the various States. Nearly every State had a different instrument or had a different method of using the same instrument; so, for years there has been a controversy regarding the proper method and instruments to use in determining flash and fire tests.

Fifteen years ago, practically all the lubricating oils came from the Pennsylvania fields and were therefore generally uniform. As a result of using one crude oil, the various refiners put out practically the same oils and regularly-marketed brands became standard for the jobbing trade, such as "25 Gravity Paraffine," or "885 Paraffine Oils," named for the Baumé and specific gravity of the two respective oils. These oils, which in time were produced by various refiners under a general classification that was entirely the result of trade custom, were somewhat uniform. Oils were sold to the consuming trade under trademarks or names designating general uses that, as a rule, were not the same as the designations used by the refiners or the jobbers. These oils were standardized by the different marketers according to their formula cards, and the readings were used only to keep consecutive shipments of the same brand within prescribed limits. It was never intended that the specifications developed in this manner would be used by the consumer, and for this reason the readings were never given out. Consumers, however, eventually came to the point of issuing specifications. These first specifications called for blends of a certain percentage of some particular local crude with other combinations generally impossible for the majority of refiners to secure or furnish. It seemed as if such specifications had been issued on the advice of some one marketer who was manufacturing that particular combination, therefore making certain that he would retain the business. Or, the specification would minutely describe within limits impossible to manufacture generally some one well-established brand that was being used by the purchaser who wished it duplicated. These specifications usually stated that certain penalties would follow deliveries not meeting specification. Such specifications were practically unworkable for the large refiner, and there was a serious question in regard to the interpretation of the terms. As a rule the instruments used would not be mentioned in the specification, and even the temperatures at which the viscosities were to be taken would be omitted, producing a puzzle requiring the services of a mind reader to interpret the wants of the customer.

Oils from New Fields Barred Out

When the new oil fields were discovered in California, Texas and the Middle-West, producing oils which had entirely different physical characteristics from the Pennsylvania crudes, the specifications established and used by the various industries in purchasing their supplies very effectively barred the new oils. Combating Pennsylvania specifications was probably the hardest task that fell to the lot of the marketers of the newer oils, and it required constant and expert attention to change this situation. It was necessary to run many comparative tests to prove that oils not meeting the authorized specifications would meet the mechanical needs of the machinery, and in this way it was possible sometimes to have the specifications changed so as to admit the new oils. Many times the revised specifications, when finished, could have read simply "oil," as they were so broadly drawn as to be practically no specification. On the other hand, specifications not broad enough to allow competition, or that require manufacturers to turn out a special oil when some stock product would meet the requirements, are practically useless. Unfortunately, the specifications used by many of the large consuming companies have been drawn up by men who were not entirely familiar with this work. Usually they have been men who were familiar with only one class of product and the specification was therefore only a straight reading of that product; consequently, the business might as well have been awarded to the manufacturer of that particular product without the trouble of issuing a specification. At times they have been men with a smattering of knowledge of the oil business who would draw up a specification broad enough in several particulars to admit wide competition and then, by one feature, such as the flash or the cold test, place a limitation on the products available until competition would narrow down to a very small field of bidders.

For this reason, the large manufacturers who had an established trade for their regular trademarked brands usually threw aside specifications in disgust. Many times the small marketing companies, that had no established manufacturing and distributing limits, would adjust their particular products to meet the specification, and most of the specification business went to that class of manufacturer. Specifications that were interpretable often would not allow the slightest variation. The consequence was that the manufacturer, although he had a very similar product that would easily handle the work in hand, would find himself faced with the necessity of making an entirely new product, thus adding another brand to a probably already overcrowded manufacturing and price list. From an economic standpoint, this was not a desirable thing to do. The general acceptance of specifications was discouraged as a policy by the industry, the refiners generally taking the stand that writing specifications should be left to the discretion of the oil refiner for his own particular use and that the customer should simply ask for a product for a certain purpose, allowing the refiner or marketer to send his experienced operators into the customer's plant to designate which of the oils on his established list would do the best work. Innumerable instances were also found where specifications, which were used to facilitate purchases, did not cover oils that were entirely suited for the machinery in the plants and, as a result of mechanical troubles, other oils would be purchased entirely opposite to the specifica-

tion. This resulted in many heated discussions between the purchasing agents, plant engineers and oil-company representatives.

There is no question that properly drawn specifications which actually represent lubricants satisfactory for operating conditions would help the refiner and make his work more simple. They would also be a help to the purchaser as, under such specifications, he could be sure of purchasing oils of certain classifications which he had already determined either by trial or builders' recommendation were suitable for the machinery in his plant.

Many points should be taken into consideration in drawing up specifications. They must be simple and readily interpreted by the trade. They must be broad enough to allow bids on suitable oils from all crudes. Further, they must be worded so as to call for low-priced, medium and high-priced oils, according to the work to be done. For instance, oils that are intended for ordinary lubrication and oils for special requirements such as turbines and internal-combustion engines, might have the same flash and fire, viscosity and cold tests; yet the oil for the special work would have been refined so that it would handle the severe conditions. As a consequence of this special refining the manufacturing cost of this oil would be increased, and it therefore would come into the high or medium-priced classification as compared to the oil for ordinary lubrication.

Government Specifications

That specifications can be written so that they describe the oil required, and yet allow wide competition, is shown by the War Department specifications. When the first specifications were drawn up during the war, it was necessary to have a minimum number of grades and each oil was made to cover as wide a range as possible. Where it was possible to use the more expensive oils for purposes where ordinarily cheap oils would be used, this was done, as it was considered that the increased cost in using the expensive oil was more than offset by the cost of handling additional brands under war conditions. This was especially true of the specifications covering engine oil, which was used as widely as possible in substitution for the numerous cheaper oils for various uses and, as the greatest gallonage was to be used for the motor-transport units, the oil necessary for that equipment was considered more or less as standard and used for many purposes. The Navy Department also follows this practice of using the high-class oils for less-important lubrication; for instance, turbine oil will probably be used for machine-shop lubrication because it simplifies the storage and makes impossible the danger of getting an ordinary machine-shop oil in the turbines, as one such performance would more than offset a year's savings on purchases of the cheaper oil.

The specifications at present used by the War Department have been drawn up to cover three classes of oils which will fall under grade or price classification. This is covered practically as follows:

> Class A states that the oil is required for general lubrication of engines and machines where a highly-refined oil is not required. This means that a cheap red oil, of the viscosity mentioned, would be suitable
>
> Class B states that the oil is to be better than Class A oil. This specification also includes an emulsion test which would necessitate a better oil than is furnished under Class A
>
> Class C covers oils suitable for lubrication of air compressors and internal-combustion engines, and is also suitable for turbines, dynamos, high-speed engines, forced-feed systems and the like, where a better lubricant than Class B oil is required. In addition to the tests required under Class A and Class B a carbon test is included which will insure that the oil furnished be a highly-refined filtered product, entirely suitable for this class of work

Under each of these classes the oil is divided into five grades, with the following viscosity range at 100 deg. fahr. Saybolt universal:

Grade	*Saybolt Sec.*
Extra light	140 to 160
Light	175 to 210
Medium	275 to 310
Heavy	370 to 410
Extra heavy	470 to 520

The flash and fire, and the cold-test range of all three grades are also the same. The refining requirements, as expressed in the acidity, emulsion and carbon tests, bring these classes of oil into different finished products which will vary through a wide range as to operating results secured and as to prices. Eventually, the specifications will probably be reduced to two. Class A will be a cheap oil for ordinary purposes and Class C an oil for turbines, motors, dynamos and the like. These specifications are drawn so that they will admit suitable oils made from all crudes, which illustrates the point that this is possible if the necessary attention and knowledge enter into the transaction.

Committee D-2 of the American Society for Testing Materials for the establishment of methods and instruments has already reported upon and adopted many of the main instruments and methods. The Bureau of Standards at Washington should be the natural authority to confer with to get the proper interpretation and to secure standard samples and readings on uniformly standard instruments so that any laboratory can check its instruments. The Navy Department and the War Department specifications, which have been written with the aid of the petroleum industry and generally accepted by them, can be taken as a general guide to specification writers as acceptable in form and nomenclature. It then remains for the engine builder to select the classification and grade of oil that will best suit the condition of his machinery when new and after it is well worked in, and this had best be done with the assistance of the many able lubrication engineers in the petroleum industry. After this, the machines can be marked with the established classification and grade of oil according to Army specifications, or other standards that may be generally accepted, and this will be the guide which the oil manufacturer will gladly use in selling oil to the owner and operator of the machine.

Military and Commercial Motor Transportation[1]

By Col. B. Taylor, U.S.A.

By urging standardization, pooling and combining operation and maintenance in a motor transport corps during the war, those officers who were charged with organization and operation excited great opposition and distrust from those who operated locally. In the most successful motor transport organization in France, three main divisions of motor transportation were considered, operation, maintenance and administration, with full controlling authority over both operation and maintenance vested in the administrative head. Organizers who failed to place full control over driver and mechanic in one authority found waste and excessive extravagance for which responsibility could not be fixed, and the full operative power of the organization was lost. Within the simple triangular organization of operation, maintenance and administration, there were many auxiliary functions to be considered carefully and provided for.

The number of spare parts required for repair and maintenance by any one vehicle had to be multiplied by the number of different makes of vehicle serving in a section, approximately 200. For practical purposes, but 30-odd principal makes were considered. Although among the 10,000 officers and men serving in the Motor Transport Corps advance section there were experts from all branches of the automobile industry, it was impossible to find anyone who had handled the supplies of more than half a dozen makes of vehicle in commercial life. The handling of so many parts of so many different types and makes was very confusing to all who struggled with the problem, and bitter complaints from divisions hard pressed for transportation never ceased.

For convenience, assume the average number of spare parts for a motor vehicle is 2500, with 80 per cent non-interchangeable. Therefore, 400,000 different items in automotive supplies to be produced, shipped, stored and issued in various quantities, had to be considered if all the vehicles in use were to be maintained. Of these, the greatest number we were able to obtain from the United States was a little less than 90,000. Under the conditions which existed the procurement, shipment, storage and issue of the number of parts required for the upkeep of motor vehicles used by the armies in operation against the enemy, constituted a problem impossible of solution. Standardization and reduction of motor vehicles to extremely few makes was obviously necessary. To enable a park to make all repairs that might be required of it by divisions in its vicinity, it would have been necessary to fill its storerooms with sufficient quantities of spare parts for 20 or 30 different makes of vehicle; an impossibility.

The spare-parts problem was simply a hopeless maze of confusion because of our failure to provide standardized motor transportation before the war. It was further complicated by waste in unorganized operation and the fact that no one authority was given the power to control and coordinate the relation between procurement, shipment, distribution, operation, repair and salvage.

The simple question is always asked, "Why not reduce the number of vehicles to one or two, or half a dozen makes for future military service?" The service is bending every effort toward such reduction by standardization. The desire within the Army of officers of different branches to enforce their individual ideas for the adoption of the make and type or special design most favored by them, is in itself difficult to overcome. Further, there is the pressure from without to adopt the makes and types in which manufacturers and supply agencies are interested. Regardless of the merits of this or that vehicle or make and individual ideas and interest, it is absolutely certain that unless the number of makes of vehicle employed by the Army in time of war is reduced to a practical minimum, failure of motor transportation will be only a matter of time, leading inevitably to failure of both the supply branch and the combat branch of the Army. The point at which the necessary mobility of an attacking army is reduced so that further advance or even retreat is impossible, was uncomfortably close in our armies when the armistice was signed on Nov. 11, 1918. This was due mostly to the lack of preparedness in the United States for military transportation. Within the Army, lack of proper organization of operation and maintenance functions of motor transportation under one executive authority, and lack of coordination of all auxiliary functions, embraced all difficulties of any consequence. It is positively a patriotic duty that, in the future military use of motor vehicles, all Americans combine to reduce the number of makes and spare parts employed by the Army to the lowest possible minimums. If the importance of standardization is disregarded, commercial transportation will suffer nearly as much as we did in the Army. The development of operative power and capacity is only just beginning. The organization of operation and maintenance under one controlling authority and the coordination of independent interests in developing motor transportation seems not to have been very widely or deeply considered.

[1]From an address at the Highway Transport Conference, National Automobile Chamber of Commerce.

MINERAL PRODUCTS

The following figures are given by the Bureau of Mines as the annual value of mineral products in the United States:

	Value of Product	*Percentage of Total*
Coal	$1,801,480,347	32.63
Petroleum	690,190,000	12.51
All other non-metallic	874,653,000	15.84
Pig iron and ferroalloys	1,296,193,500	23.47
All other metallic	856,945,500	15.55
Total	$5,519,462,347	100.00

Tentative Report of the National Screw Thread Commission

THE National Screw Thread Commission desires to make the information contained in its progress report immediately available to American manufacturers. Rather than delay submitting the report while considering the possibilities of international standardization of screw threads more fully, a tentative report has been made outlining in detail the work accomplished by the Commission. Since the report will not be available in printed form for some time, a brief abstract of that portion which is of the most interest to automotive engineers follows.

Form of Thread and Sizes

The United States Standard or Sellers' profile is recommended by the Commission as the National form of thread. This profile is to be used for all screw-thread work except where otherwise specified for special purposes. The basic angle of thread is 60 deg. between the sides of the thread measured in an axial plane. The line bisecting this 60-deg. angle is perpendicular to the axis of the screw threads. The basic flat at the root and crest of the thread form is one-eighth of the pitch. The basic depth of the thread form is $0.649519p$ or $0.649519/n$ where p equals the pitch in inches and n equals the number of threads per inch.

A clearance is provided at the minor diameter of the nut by removing the thread form at the crest by an amount equal to one-sixth to one-fourth of the basic thread depth. A clearance at the major diameter of the nut is provided by decreasing the depth of the truncation triangle by an amount equal to one-third to two-thirds of its theoretical value.

It is the aim of the Commission in establishing thread systems for adoption and general use, to eliminate all unnecessary sizes and in addition to utilize, as far as possible, present predominating sizes. While from certain standpoints it would have been desirable to make simplifications in the thread systems and to establish standards which are more thoroughly consistent, it is believed that any radical change at present would be out of place, interfere with manufacturing conditions and involve great economic loss.

TABLE 1—NATIONAL COARSE-THREAD SERIES

Identification		Basic Diameters			Thread Data		
Numbered and Fractional Sizes	n Number of Threads per Inch	D Major Diam.	E Pitch Diam.	K Minor Diam.	Metric Equivalent of Major Diam.	p Pitch	h Depth of Thread
		In.	In.	In.	Mm.	In.	In.
1	64	0.0730	0.0629	0.0527	1.854	0.0156250	0.0101
2	56	0.0860	0.0744	0.0628	2.184	0.0178571	0.0116
3	48	0.0990	0.0855	0.0719	2.515	0.0208333	0.0135
4	40	0.1120	0.0958	0.0795	2.845	0.0250000	0.0162
5	40	0.1250	0.1088	0.0925	3.175	0.0250000	0.0162
6	32	0.1380	0.1177	0.0974	3.505	0.0312500	0.0203
8	32	0.1640	0.1437	0.1234	4.166	0.0312500	0.0203
10	24	0.1900	0.1629	0.1359	4.826	0.0416667	0.0271
12	24	0.2160	0.1889	0.1619	5.486	0.0416667	0.0271
1/4	20	0.2500	0.2175	0.1850	6.350	0.0500000	0.0325
5/16	18	0.3125	0.2764	0.2403	7.938	0.0555556	0.0361
3/8	16	0.3750	0.3344	0.2938	9.525	0.0625000	0.0406
7/16	14	0.4375	0.3911	0.3447	11.113	0.0714286	0.0464
1/2	13	0.5000	0.4500	0.4001	12.700	0.0769231	0.0500
9/16	12	0.5625	0.5084	0.4542	14.288	0.0833333	0.0541
5/8	11	0.6250	0.5660	0.5069	15.875	0.0909091	0.0590
3/4	10	0.7500	0.6850	0.6201	19.050	0.1000000	0.0650
7/8	9	0.8750	0.8028	0.7307	22.225	0.1111111	0.0722
1	8	1.0000	0.9188	0.8376	25.400	0.1250000	0.0812
1 1/8	7	1.1250	1.0322	0.9394	28.575	0.1428571	0.0928
1 1/4	7	1.2500	1.1572	1.0644	31.750	0.1428571	0.0928
1 1/2	6	1.5000	1.3917	1.2835	38.100	0.1666667	0.1083
1 3/4	5	1.7500	1.6201	1.4902	44.450	0.2000000	0.1299
2	4½	2.0000	1.8557	1.7113	50.800	0.2222222	0.1443
2 1/4	4½	2.2500	2.1057	1.9613	57.150	0.2222222	0.1443
2 1/2	4	2.5000	2.3376	2.1752	63.500	0.2500000	0.1624
2 3/4	4	2.7500	2.5876	2.4252	69.850	0.2500000	0.1624
3	4	3.0000	2.8376	2.6752	76.200	0.2500000	0.1624

TABLE 2—NATIONAL FINE-THREAD SERIES

Identification		Basic Diameters			Thread Data		
Numbered and Fractional Sizes	n Number of Threads per Inch	D Major Diam.	E Pitch Diam.	K Minor Diam.	Metric Equivalent of Major Diam.	p Pitch	h Depth of Thread
		In.	In.	In.	Mm.	In.	In.
0	80	0.0600	0.0519	0.0438	1.524	0.0125000	0.00812
1	72	0.0730	0.0640	0.0550	1.854	0.0138889	0.00902
2	64	0.0860	0.0759	0.0657	2.184	0.0156250	0.01014
3	56	0.0990	0.0874	0.0758	2.515	0.0178571	0.01160
4	48	0.1120	0.0985	0.0849	2.845	0.0208333	0.01353
5	44	0.1250	0.1102	0.0955	3.175	0.0227273	0.01476
6	40	0.1380	0.1218	0.1055	3.506	0.0250000	0.01624
8	36	0.1640	0.1460	0.1279	4.166	0.0277778	0.01804
10	32	0.1900	0.1697	0.1494	4.826	0.0312500	0.02030
12	28	0.2160	0.1928	0.1696	5.486	0.0357143	0.02319
1/4	28	0.2500	0.2268	0.2036	6.350	0.0357143	0.02319
5/16	24	0.3125	0.2854	0.2584	7.938	0.0416667	0.02706
3/8	24	0.3750	0.3479	0.3209	9.525	0.0416667	0.02706
7/16	20	0.4375	0.4050	0.3725	11.113	0.0500000	0.03248
1/2	20	0.5000	0.4675	0.4350	12.700	0.0500000	0.03248
9/16	18	0.5625	0.5264	0.4903	14.288	0.0555556	0.03608
5/8	18	0.6250	0.5889	0.5528	15.875	0.0555556	0.03608
3/4	16	0.7500	0.7094	0.6688	19.050	0.0625000	0.04060
7/8	14	0.8750	0.8286	0.7822	22.225	0.0714286	0.04640
1	14	1.0000	0.9536	0.9072	25.400	0.0714286	0.04640
1 1/8	12	1.1250	1.0709	1.0167	28.575	0.0833333	0.05413
1 1/4	12	1.2500	1.1959	1.1417	31.750	0.0833333	0.05413
1 1/2	12	1.5000	1.4459	1.3917	38.100	0.0833333	0.05413
1 3/4	12	1.7500	1.6959	1.6417	44.450	0.0833333	0.05413
2	12	2.0000	1.9459	1.8917	50.800	0.0833333	0.05413
2 1/4	12	2.2500	2.1959	2.1417	57.150	0.0833333	0.05413
2 1/2	12	2.5000	2.4459	2.3917	63.500	0.0833333	0.05413
2 3/4	12	2.7500	2.6959	2.6417	69.850	0.0833333	0.05413
3	10	3.0000	2.9350	2.8701	76.200	0.1000000	0.06495

The testimony given at the various hearings held by the Commission was very consistent in favoring the maintenance of the present coarse and fine-thread series. The coarse-thread series, Table 1, consists of the present United States Standard threads, supplemented in the sizes below ¼ in. by the standard established by the American Society of Mechanical Engineers. Only those sizes which are essential are included in the National Coarse-Thread Series.

This series is recommended for general use in engineering work; in machine construction where conditions are favorable to the use of bolts, screws and other threaded components and where quick and easy assembly of the parts is desired; and for all work where conditions do not require the use of fine-pitch threads.

The National Fine-Thread Series, Table 2, contains certain sizes known as the S. A. E. threads, and also certain sizes known as the A. S. M. E. machine-screw sizes. This series does not include the 11/16, 1⅜, 1⅝, 1⅞, 2⅛, 2⅜, 2⅝, 2⅞ and 3½-in. and larger S. A. E. screw-thread sizes. The series is recommended for general use in automotive and aircraft work; for use where the design requires both strength and reduction in weight and where special conditions require a fine thread, such as, for instance, on large sizes where sufficient force cannot be applied by exerting the strength of a man on an ordinary wrench to tighten a screw or bolt of coarse pitch properly.

The report also includes thread series known as the Na-

TABLE 3—REGULAR MEDIUM-FIT NATIONAL FINE-THREAD SERIES (Dimensions in inches)

Numbered and Fractional Sizes	Number of Threads per Inch	SCREW SIZES						NUT SIZES					
		Major Diam		Pitch Diam		Minor Diam		Minor Diam		Pitch Diam		Major Diam	
		Max	Min	Max.	Min	Max[1]	Min	Min	Max	Min.	Max	Min[1]	Max
0	80	0.0600	0.0566	0.0519	0.0502	0.0447	0.0421	0.0465	0.0478	0.0519	0.0536	0.0609	0.0635
1	72	0.0730	0.0694	0.0640	0.0622	0.0560	0.0532	0.0580	0.0595	0.0640	0.0658	0.0740	0.0768
2	64	0.0860	0.0822	0.0759	0.0740	0.0668	0.0638	0.0691	0.0708	0.0759	0.0778	0.0871	0.0902
3	56	0.0990	0.0950	0.0874	0.0854	0.0771	0.0738	0.0797	0.0816	0.0874	0.0894	0.1003	0.1036
4	48	0.1120	0.1076	0.0985	0.0963	0.0864	0.0827	0.0894	0.0917	0.0985	0.1007	0.1135	0.1172
5	44	0.1250	0.1204	0.1102	0.1079	0.0971	0.0932	0.1004	0.1029	0.1102	0.1125	0.1266	0.1306
6	40	0.1380	0.1332	0.1218	0.1194	0.1073	0.1031	0.1109	0.1136	0.1218	0.1242	0.1398	0.1440
8	36	0.1640	0.1590	0.1460	0.1435	0.1299	0.1254	0.1339	0.1369	0.1460	0.1485	0.1660	0.1705
10	32	0.1900	0.1846	0.1697	0.1670	0.1517	0.1467	0.1562	0.1596	0.1697	0.1724	0.1923	0.1972
12	28	0.2160	0.2098	0.1928	0.1897	0.1722	0.1665	0.1773	0.1812	0.1928	0.1959	0.2186	0.2243
1/4	28	0.2500	0.2438	0.2268	0.2237	0.2062	0.2005	0.2113	0.2152	0.2268	0.2299	0.2526	0.2583
5/16	24	0.3125	0.3059	0.2854	0.2821	0.2614	0.2551	0.2674	0.2719	0.2854	0.2887	0.3155	0.3218
3/8	24	0.3750	0.3684	0.3479	0.3446	0.3239	0.3176	0.3299	0.3344	0.3479	0.3512	0.3780	0.3843
7/16	20	0.4375	0.4303	0.4050	0.4014	0.3762	0.3689	0.3834	0.3888	0.4050	0.4086	0.4411	0.4483
1/2	20	0.5000	0.4928	0.4675	0.4639	0.4387	0.4314	0.4459	0.4513	0.4675	0.4711	0.5036	0.5108
9/16	18	0.5625	0.5543	0.5264	0.5223	0.4943	0.4862	0.5024	0.5084	0.5264	0.5305	0.5665	0.5746
5/8	18	0.6250	0.6168	0.5889	0.5848	0.5568	0.5487	0.5649	0.5709	0.5889	0.5930	0.6290	0.6371
3/4	16	0.7500	0.7410	0.7094	0.7049	0.6733	0.6643	0.6823	0.6891	0.7094	0.7139	0.7545	0.7635
7/8	14	0.8750	0.8652	0.8286	0.8237	0.7874	0.7773	0.7977	0.8054	0.8286	0.8335	0.8802	0.8902
1	14	1.0000	0.9902	0.9536	0.9487	0.9124	0.9023	0.9227	0.9304	0.9536	0.9585	1.0052	1.0152
1 1/8	12	1.1250	1.1138	1.0709	1.0653	1.0228	1.0111	1.0348	1.0438	1.0709	1.0765	1.1310	1.1426
1 1/4	12	1.2500	1.2388	1.1959	1.1903	1.1478	1.1361	1.1598	1.1688	1.1959	1.2015	1.2560	1.2676
1 1/2	12	1.5000	1.4888	1.4459	1.4403	1.3978	1.3861	1.4098	1.4188	1.4459	1.4515	1.5060	1.5176
1 3/4	12	1.7500	1.7388	1.6959	1.6903	1.6478	1.6361	1.6598	1.6688	1.6959	1.7015	1.7560	1.7676
2	12	2.0000	1.9888	1.9459	1.9403	1.8978	1.8861	1.9098	1.9188	1.9459	1.9515	2.0060	2.0176
2 1/4	12	2.2500	2.2388	2.1959	2.1903	2.1478	2.1361	2.1598	2.1688	2.1959	2.2015	2.2560	2.2676
2 1/2	12	2.5000	2.4888	2.4459	2.4403	2.3978	2.3861	2.4098	2.4188	2.4459	2.4515	2.5060	2.5176
2 3/4	12	2.7500	2.7388	2.6959	2.6903	2.6478	2.6361	2.6598	2.6688	2.6959	2.7015	2.7560	2.7676
3	10	3.0000	2.9872	2.9350	2.9286	2.8773	2.8637	2.8917	2.9026	2.9350	2.9414	3.0072	3.0208

[1]Dimensions given are figured to the intersection of the worn tool arc with a centerline through the crest and the root.

tional Fire Hose Coupling Thread, the National Hose Coupling Thread and the National Pipe Thread.

One of the most important phases of standardization of screw-thread products is that of interchangeability. The direct result of establishing a National Thread System will be the elimination of many unnecessary sizes. Of even more importance are the advantages to be gained in the manufacture of interchangeable screw-thread parts, which, having been made in different manufacturing plants at widely separated points, will assemble without difficulty and in a manner that will insure the proper operation of the mechanism being produced.

The Commission makes the broad recommendation that the minimum threaded hole or nut should correspond to the basic size, errors owing to workmanship being permitted above the basic size. The maximum length of engagement for screw threads manufactured in accordance with any of the classes of fit specified shall not exceed the quantity as determined by the formula $L=1.5\ D$ where L is the length of the engagement and D is the basic major diameter of the thread.

The loose-fit class of screw threads covers the manufacture of strictly interchangeable threaded parts where the work is produced in two or more manufacturing plants. In this class will be included threads for artillery ammunition and rough commercial work, such as stove and carriage bolts and other threaded work of a similar nature, where quick and easy assembly is necessary and a certain amount of shake or play is not objectionable.

National Straight Pipe Threads and National Hose Coupling Threads are produced in this class of fit only.

The regular medium-fit class, Table 3, is intended to apply to interchangeable manufacture where the threaded members are to be assembled nearly, or entirely, with the fingers and where a moderate amount of shake or play between the assembled threaded members is not objectionable. This class will include the great bulk of fastening screws for instruments, small arms and other ordnance material, such as gun carriages, aerial bomb dropping devices and interchangeable accessories mounted on guns, machine and cap screws, screws for sewing machines and typewriters and other work of a similar nature.

The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter specified in the tables of thread systems which are computed from the basic major diameter of the thread to be manufactured. The major diameter and pitch diameter of the maximum screw of a given pitch and diameter will correspond to the basic dimensions specified in the tables of thread systems which are computed from the basic major diameter of the thread to be manufactured. The tolerance on the nut will be plus, applied from the basic size to above basic size. The tolerance on the screw will be minus, applied from the basic size to below basic size. The allowance between the size of the maximum screw and the minimum nut will be zero for all pitches and all diameters.

The special medium-fit class, Table 4, applies especially to the higher grade of automobile screw-thread work. It is the same in every particular as the regular medium-fit class except that the tolerances are smaller.

The close-fit class, Table 5, is intended for threaded work of the finest commercial quality, where the thread has practically no backlash, and for light screw-driver fits. In the manufacture of screw-thread products belonging in this class, it will be necessary to use precision tools, selected master gages and many other refinements. This quality of work should, therefore, be used only in cases where requirements of the mechanism being produced are exacting, or where special conditions require screws having a precision fit. To secure the fit desired, it may be necessary, in some cases, to select the parts when the product is being assembled. The pitch diameter of the minimum nut of a given diameter and pitch will correspond to the basic pitch diameter as specified in the tables of thread systems which are computed from the basic major diameter of the thread to be manufactured. The major diameter and pitch diameter of the maximum screw of a given diameter and pitch will be above the basic dimensions as specified in the tables of thread systems which are computed from the basic major diameter of the thread to be manufactured. The tolerance on the nut will be plus, applied from the basic size to above basic size. The tolerance on the screw will be minus, applied from the maximum screw dimensions to below the maximum screw dimensions.

TABLE 4—SPECIAL MEDIUM-FIT NATIONAL FINE-THREAD SERIES (Dimensions in inches)

Numbered And Fractional Sizes	Number of Threads per Inch	SCREW SIZES						NUT SIZES					
		Major Diam		Pitch Diam		Minor Diam		Minor Diam		Pitch Diam		Major Diam	
		Max	Min	Max	Min	Max[2]	Min	Min	Max	Min	Max	Min[2]	Max
0	80	0.0600	0.0574	0.0519	0.0506	0.0447	0.0425	0.0465	0.0478	0.0519	0.0532	0.0609	0.0631
1	72	0.0730	0.0704	0.0640	0.0627	0.0560	0.0537	0.0580	0.0595	0.0640	0.0653	0.0740	0.0763
2	64	0.0860	0.0832	0.0759	0.0745	0.0668	0.0643	0.0691	0.0708	0.0759	0.0773	0.0871	0.0897
3	56	0.0990	0.0960	0.0874	0.0859	0.0771	0.0743	0.0797	0.0816	0.0874	0.0889	0.1003	0.1031
4	48	0.1120	0.1088	0.0985	0.0969	0.0864	0.0833	0.0894	0.0917	0.0985	0.1001	0.1135	0.1166
5	44	0.1250	0.1218	0.1102	0.1086	0.0971	0.0939	0.1004	0.1029	0.1102	0.1118	0.1266	0.1299
6	40	0.1380	0.1346	0.1218	0.1201	0.1073	0.1038	0.1109	0.1136	0.1218	0.1235	0.1398	0.1433
8	36	0.1640	0.1604	0.1460	0.1442	0.1299	0.1261	0.1339	0.1369	0.1460	0.1478	0.1660	0.1698
10	32	0.1900	0.1862	0.1697	0.1678	0.1517	0.1475	0.1562	0.1596	0.1697	0.1716	0.1923	0.1964
12	28	0.2160	0.2116	0.1928	0.1906	0.1722	0.1674	0.1773	0.1812	0.1928	0.1950	0.2186	0.2234
1/4	28	0.2500	0.2456	0.2268	0.2246	0.2062	0.2014	0.2113	0.2152	0.2268	0.2290	0.2526	0.2574
5/16	24	0.3125	0.3077	0.2854	0.2830	0.2614	0.2560	0.2674	0.2719	0.2854	0.2878	0.3155	0.3209
3/8	24	0.3750	0.3702	0.3479	0.3455	0.3239	0.3185	0.3299	0.3344	0.3479	0.3503	0.3780	0.3834
7/16	20	0.4375	0.4323	0.4050	0.4024	0.3762	0.3699	0.3834	0.3888	0.4050	0.4076	0.4411	0.4473
1/2	20	0.5000	0.4948	0.4675	0.4649	0.4387	0.4324	0.4459	0.4513	0.4675	0.4701	0.5036	0.5098
9/16	18	0.5625	0.5565	0.5264	0.5234	0.4943	0.4873	0.5024	0.5084	0.5264	0.5294	0.5665	0.5735
5/8	18	0.6250	0.6190	0.5889	0.5859	0.5568	0.5498	0.5649	0.5709	0.5889	0.5919	0.6290	0.6360
3/4	16	0.7500	0.7436	0.7094	0.7062	0.6733	0.6656	0.6823	0.6891	0.7094	0.7126	0.7545	0.7622
7/8	14	0.8750	0.8678	0.8286	0.8250	0.7874	0.7786	0.7977	0.8054	0.8286	0.8322	0.8802	0.8889
1	14	1.0000	0.9928	0.9536	0.9500	0.9124	0.9036	0.9227	0.9304	0.9536	0.9572	1.0052	1.0139
1 1/8	12	1.1250	1.1170	1.0709	1.0669	1.0228	1.0127	1.0348	1.0438	1.0709	1.0749	1.1310	1.1410
1 /4	12	1.2500	1.2420	1.1959	1.1919	1.1478	1.1377	1.1598	1.1688	1.1959	1.1999	1.2560	1.2660
1/2	12	1.5000	1.4920	1.4459	1.4419	1.3978	1.3877	1.4098	1.4188	1.4459	1.4499	1.5060	1.5160
1 3/4	12	1.7500	1.7420	1.6959	1.6919	1.6478	1.6377	1.6598	1.6688	1.6959	1.6999	1.7560	1.7660
2	12	2.0000	1.9920	1.9459	1.9419	1.8978	1.8877	1.9098	1.9188	1.9459	1.9499	2.0060	2.0160
2 1/4	12	2.2500	2.2420	2.1959	2.1919	2.1478	2.1377	2.1598	2.1688	2.1959	2.1999	2.2560	2.2660
2 1/2	12	2.5000	2.4920	2.4459	2.4419	2.3978	2.3877	2.4098	2.4188	2.4459	2.4499	2.5060	2.5160
2 3/4	12	2.7500	2.7420	2.6959	2.6919	2.6478	2.6377	2.6598	2.6688	2.6959	2.6999	2.7560	2.7660
3	10	3.0000	2.9910	2.9350	2.9305	2.8773	2.8656	2.8917	2.9026	2.9350	2.9395	3.0072	3.0189

[2]Dimensions given are figured to the intersection of the worn tool arc with a centerline through the crest and the root.

The wrench-fit class covers the manufacture of threaded parts ¼ in. in diameter or larger which are to be assembled permanently with a wrench. Since the material is an important factor in determining the fit between the threaded members, two subdivisions are provided for this class of work, differing mainly in the amount of the allowance or interference values provided for different pitches. The first subdivision provides for the production of interchangeable wrench-fit screws or studs used in light sections with moderate stresses, such as in aircraft and automobile engine work; the other covers the production of interchangeable wrench-fit screws or studs used in heavy sections with heavy stresses, such as in steam engine and heavy hydraulic work.

The pitch diameter of the minimum nut of a given diam-

TABLE 5—CLOSE-FIT NATIONAL FINE-THREAD SERIES (Dimensions in inches)

Numbered and Fractional Sizes	Number of Threads per Inch	SCREW SIZES						NUT SIZES					
		Major Diam		Pitch Diam		Minor Diam		Minor Diam		Pitch Diam		Major Diam	
		Max	Min	Max	Min	Max[3]	Min	Min	Max	Min	Max	Min[2]	Max
0	80	0.0601	0.0589	0.0520	0.0514	0.0448	0.0433	0.0465	0.0478	0.0519	0.0525	0.0609	0.0624
1	72	0.0731	0.0717	0.0641	0.0634	0.0561	0.0544	0.0580	0.0595	0.0640	0.0647	0.0740	0.0757
2	64	0.0861	0.0847	0.0760	0.0753	0.0669	0.0651	0.0691	0.0708	0.0759	0.0766	0.0871	0.0890
3	56	0.0992	0.0978	0.0876	0.0869	0.0773	0.0753	0.0797	0.0816	0.0874	0.0881	0.1003	0.1023
4	48	0.1122	0.1106	0.0987	0.0979	0.0866	0.0843	0.0894	0.0917	0.0985	0.0993	0.1135	0.1158
5	44	0.1252	0.1236	0.1104	0.1096	0.0973	0.0949	0.1004	0.1029	0.1102	0.1110	0.1266	0.1291
6	40	0.1382	0.1364	0.1220	0.1211	0.1075	0.1048	0.1109	0.1136	0.1218	0.1227	0.1398	0.1425
8	36	0.1642	0.1624	0.1462	0.1453	0.1301	0.1272	0.1339	0.1369	0.1460	0.1469	0,1660	0.1689
10	32	0.1902	0.1882	0.1699	0.1689	0.1519	0.1486	0.1562	0.1596	0.1697	0.1707	0.1923	0.1955
12	28	0.2162	0.2140	0.1930	0.1919	0.1724	0.1687	0.1773	0.1812	0.1928	0.1939	0.2186	0.2223
1/4	28	0.2502	0.2480	0.2270	0.2259	0.2064	0.2027	0,2113	0.2152	0.2268	0.2279	0.2526	0.2563
5/16	24	0.3128	0.3104	0.2857	0.2845	0.2617	0.2575	0.2674	0.2719	0.2854	0.2866	0.3155	0.3197
3/8	24	0.3753	0.3729	0.3482	0.3470	0.3242	0.3200	0.3299	0.3344	0.3479	0.3491	0.3780	0.3822
7/16	20	0.4378	0.4352	0.4053	0.4040	0.3765	0.3715	0.3834	0.3888	0.4050	0.4063	0.4411	0.4460
1/2	20	0.5003	0.4977	0.4678	0.4665	0.4390	0.4340	0.4459	0.4513	0.4675	0.4688	0.5036	0.5085
9/16	18	0.5628	0.5598	0.5267	0.5252	0.4946	0.4891	0.5024	0.5084	0.5264	0.5279	0.5665	0.5720
5/8	18	0.6253	0.6223	0.5892	0.5877	0.5571	0.5516	0.5649	0.5709	0.5889	0.5904	0.6290	0.6345
3/4	16	0.7504	0.7472	0.7098	0.7082	0.6737	0.6676	0.6823	0.6891	0.7094	0.7110	0.7545	0.7606
7/8	14	0.8754	0.8718	0.8290	0.8272	0.7878	0.7808	0.7977	0.8054	0.8286	0.8304	0.8802	0.8871
1	14	1.0004	0.9968	0.9540	0.9522	0.9128	0.9058	0.9227	0.9304	0.9536	0.9554	1.0052	1.0121
1 1/8	12	1.1255	1.1215	1.0714	1.0694	1.0233	1.0152	1.0348	1.0438	1.0709	1.0729	1.1310	1.1390
1 1/4	12	1.2505	1.2465	1.1964	1.1944	1.1483	1.1402	1.1598	1.1688	1.1959	1.1979	1.2560	1.2640
1 1/2	12	1.5005	1.4965	1.4464	1.4444	1.3983	1.3902	1.4098	1.4188	1.4459	1.4479	1.5060	1.5140
1 3/4	12	1.7505	1.7465	1.6964	1.6944	1.6483	1.6402	1.6598	1.6688	1.6959	1.6979	1.7560	1.7640
2	12	2.0005	1.9965	1.9464	1.9444	1.8983	1.8902	1.9098	1.9188	1.9459	1.9479	2.0060	2.0140
2 1/4	12	2.2505	2.2465	2.1964	2.1944	2.1483	2.1402	2.1598	2.1688	2.1959	2.1979	2.2560	2.2640
2 1/2	12	2.5005	2.4965	2.4464	2.4444	2.3983	2.3902	2.4098	2.4188	2.4459	2.4479	2.5060	2.5140
2 3/4	12	2.7505	2.7465	2.6964	2.6944	2.6483	2.6402	2.6598	2.6688	2.6959	2.6979	2.7560	2.7640
3	10	3.0006	2.9960	2.9356	2.9333	2.8779	2.8684	2.8917	2.9026	2.9350	2.9373	3.0072	3.0167

[3]Dimensions given are figured to the intersection of the worn tool arc with a centerline through the crest and the root.

eter and pitch for threads belonging in either subdivision will correspond to the basic pitch diameter as specified in the tables of thread systems which are computed from the basic major diameter of the thread to be manufactured. The major diameter and pitch diameter of the maximum screw of a given diameter and pitch for threads belonging in either subdivision will be above the basic dimensions as specified in the tables of thread systems which are computed from the basic major diameter of the thread to be manufactured. The tolerance on the nut will be plus applied from the basic size to above basic size. The tolerances on the screw will be minus applied from the maximum screw dimensions to below maximum screw dimensions.

At present the Commission does not have sufficient information or data to include in its tentative report values for tolerances and allowances for wrench fits. It is hoped, however, that sufficient information resulting from investigation and research will enable the Commission to decide, at an early date, the allowance and tolerance values for the two classes of wrench fits, which will be applicable to the various materials and which will meet the requirements found in manufacture of machines or products requiring wrench fits.

The report specifies three different sets of tolerances for use in connection with the various fits established. These represent the extreme variations allowed on the work, or in reality, the sizes of the "go" and "not go" master gages. Errors in the lead and the angle which occur can be offset by a suitable alteration of the pitch diameter of the work. Interchangeability is secured if the "go" gage passes the threaded work, although the thread profile may differ from that of the "go" gage in either pitch diameter, lead or angle. The "not go" gage checks pitch diameter only and insures that the pitch diameter is such that the fit will not be too loose.

The tolerances established for the loose and medium-fit classes permit the use of commercial taps now obtainable from various manufacturers. For the close-fit class, where it is desired to produce a hole that is close to the basic size, it is recommended that a selected tap be used.

Gages

It is not the desire of the Commission, nor is it wise at present, to lay down hard and fast specifications of a gaging system to meet the requirements of various manufacturers. To do this would not only cause hardship in certain lines of industry, but also would tend to limit progress in this important subject connected so closely with quantity production. At present the use of gages is the only known means of securing interchangeability; therefore certain fundamentals are specified which will serve as a unification of various gaging systems now in use by manufacturers in this country. A complete gaging system which has been found adequate in the production of war material is given in detail in the appendix of the report.

The standard master gage is the one to which all other gages and all dimensions of the mating parts are ultimately checked or referred either by a direct check or by comparative measurements. It clearly establishes the low limit of the threaded hole and the high limit of the screw at the point at which interference begins between mating parts. The tolerance limits of the components as physically represented by the limit master gages must never be exceeded by error or wear of the gages. "Go" gages are absolutely essential to prevent interference of mating parts and "not go" gages are essential to prevent excessive shake, play or looseness of the mating parts as determined by the extreme component limits.

The standard master gage is a threaded plug representing precisely all physical dimensions of the nominal or basic size of the threaded component. In order that the standard master gage be authentic, the deviations of this gage from the exact standard should be ascertained by the Bureau of Standards and the gage should be used with a knowledge of these deviations. The limit master gages are threaded plugs representing precisely the exact limiting physical dimensions of the threaded mating parts as established by the specified tolerances. Inspection gages are for the use of the purchaser in accepting the product. Working gages are used by the manufacturer to check the parts as they are machined.

OBTAINING ALCOHOL FROM COKE-OVEN GAS

THE fact that alcohol can be obtained from the ethylene in coke-oven gas has been known for some time. The February, 1920, issue of *Revue de Metallurgie* has an interesting article on this subject by E. de Loisy in which attention is drawn to a curious coincidence. On Dec. 15, 1919, Henry Le Chatelier presented a note to the Academy of Sciences in Paris by Monsieur de Loisy on an industrial process for the synthetic manufacture of alcohol from the gas obtained on the distillation of coal. The same day a paper was read on the same subject before the Cleveland Institute of Engineers, England, by E. Bury and O. Ollander. The article in the Revue gives an abstract of the English paper and also a copy of the note presented to the Academy of Sciences, so that a comparison can be made.

The normal quantity of ethylene and its homologues present in coke-oven gas from the Durham coals is approximately 2 per cent by volume. An ordinary chemical works efficiency of 70 per cent absorption of this gas as ethyl-hydrogen-sulphate, and a 70 per cent conversion of the latter to alcohol, would give a yield of 1.6 gal. of absolute alcohol per ton of coal charged in the coke ovens. A coke-oven plant of the size at Skinningrove, using 5800 tons of coal would produce 9200 gal. per week.

Use As Engine Fuel

During the discussion of the English paper it was claimed that the yield of alcohol mentioned, when mixed with benzol, would produce the most perfect engine fuel, from the standpoint of quality, yet devised and also that ethylene is the starting point of many reactions producing such valuable substances as chloroform, iodoform, acetic acid and acetone; all wanted in large quantities, and many of them having high monetary value. These large scale experiments have satisfied Messrs. Bury and Ollander that cheap alcohol can be made from coal gas on an industrial scale. A number of chemical engineering difficulties present themselves in working out the large scale process, but nothing which is in the least degree insurmountable.

Monsieur de Loisy was inspired by the work done by the great Berthelot on the synthetic production of alcohol, and by the large total amount of ethylene available in the gas produced by coke ovens and gas works. Although only present to the extent of about 2 per cent by volume, yet the total amount reaches very large figures. On a trip to England in December, 1918, he learned of the work being done in absorbing ethylene direct by charcoal. On his return he decided sulphuric acid would be a better absorbent, if the extreme slowness of absorption could be overcome. He therefore experimented with the use of various catalytic agents, and was finally successful in finding one cheap enough so that its regeneration was not necessary and so effective that he claims the absorption is comparable to that of carbonic acid by a potash solution. The name of this catalytic agent is not given. To make the process practical de Loisy would use the spent acid, from which the alcohol has been distilled, in the manufacture of sulphate of ammonia, or better still also use this acid to absorb moisture and any traces of benzol, acetylene, etc., from the gas from the benzol plant, before the gas passes to the concentrated acid for ethylene absorption. One per cent of the catalytic agent is necessary, and with laboratory apparatus of the simplest description small quantities of pure ethyl alcohol have been made by this method, for several months, from the ordinary city gas of Paris.—George B. Waterhouse in *The Iron Age.*

The New Army Light Artillery Tractor

By G. R. PENNINGTON[1] AND S. K. WELLMAN[2]

Illustrated with PHOTOGRAPHS AND DRAWINGS

THIS tractor is the one which we have newly developed to replace the six-horse teams which have heretofore pulled the light artillery pieces such as the 3-in. and 75-mm. field guns and their caissons. The original specifications for this tractor laid down by Col. L. B. Moody, chief of the Tank, Tractor and Trailer Division, were only that it should equal the performance of the horse teams in all respects; that it

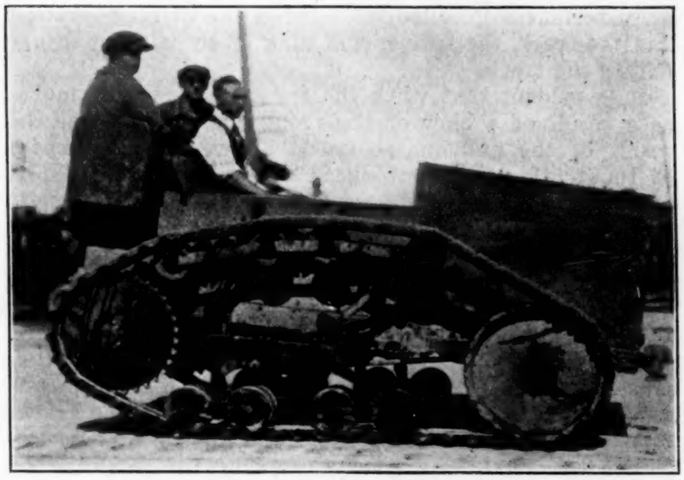


FIG. 1

should be able to cross the same hills, broken country, swampy land, and ford the same streams, and be able to make the same speed over level ground. That this tractor has met and exceeded these specifications was evident to the many members of the Society who saw the demonstration of the two experimental models at the Summer Meeting at Ottawa Beach, Mich. These tractors were driven over the road from Cleveland to Ottawa Beach for the purpose of this demonstration. It is an interesting fact to note that one of them started its run of 350 miles directly from the assembly floor, and completed it without mechanical trouble.

The tractor, which is shown in Fig. 1, is of the track-layer type. It differs radically from the previous designs of that type, however, in the same degree that the character of service expected of it is very different. The requirement that it must be able to follow a galloping team across country evidently demands an entirely different construction from one which would be suitable for pulling a plow. This tractor has therefore been designed along entirely new lines; and, though the performance data of previous types have been considered, no precedents of design have been followed.

The overall dimensions of the tractor were determined by the necessity of obtaining sufficient stability so that there would be no danger of overturning in going through shell-holes or over steep banks. Ability to stand on a 100 per cent grade longitudinally or an 80 per cent grade laterally was considered necessary, and to make this possible an overall length of 142½ in. and an overall width of 58 in. were chosen.

The maximum weight allowance was arbitrarily set on the assumption that a tractor should not weigh more than the load it is to tow, which was to be about 6000 lb. To meet this weight limitation in the dimensions set was a difficult problem. It was accomplished primarily by introducing the maximum degree of flexibility into the construction which, having the effect of reducing the shock stress on all parts of the vehicle, permitted these to be made of lighter sections and therefore of less weight.

SPECIAL SPRING SUSPENSION

The spring suspension chosen to give the desired degree of flexibility is shown diagrammatically in Fig. 2. It consists of a pair of crossed leaf springs on each side of the tractor. These springs are pivoted to the main frame at points *aa*. The springs are parallel and, of course, in different planes, so that they do not interfere. The vertical members *bb* are secured to the spring extremities by shackle-bolts, and are pivoted between the side-plates *cc* which carry the track rollers.

This construction serves four separate purposes; (*a*) these springs support the entire weight of the tractor and make this entire weight therefore "sprung weight"; (*b*) the construction permits individual freedom of movement of the track rollers, so that these can adjust themselves to all irregularities of the ground surface without materially affecting the distribution of load between the rollers, and no roller can at any time receive an excessive overload; (*c*) the springs hold the track rollers rigidly against lateral movement with respect to the main frame; and (*d*) while allowing the tractor to rock forward and backward to a certain degree to permit it to adjust itself to the varying drawbar pull developed, the leverage between points *aa* restricts this tendency to rock within safe and convenient limits. The pairs of crossed springs in fact take the place of the track roller frames found on previous types, with the advantage, however, of a considerable saving in the number of parts and of weight, and of construction open and accessible for cleaning and adjustment.

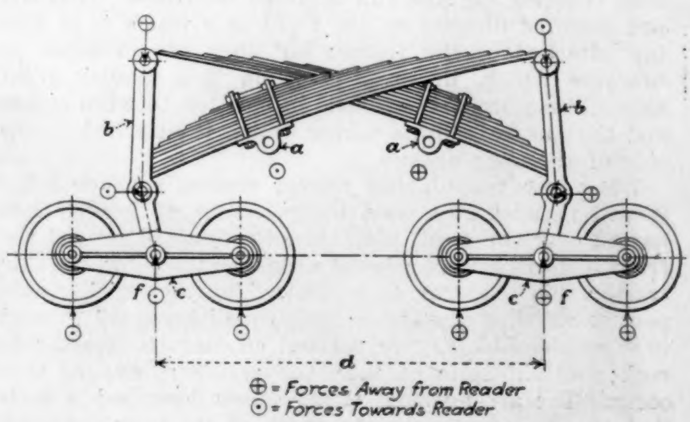


FIG. 2

[1]M. S. A. E.—Resident engineer, tank, tractor and trailer division, Ordnance Department, Cleveland.
[2]M. S. A. E.—Designing engineer, Van Dorn Iron Works Co., Cleveland.

Fig. 2 shows the way in which the springs are able to resist the lateral stresses developed, which are greatest when the tractor is turning, and result from the resistance of the ground to the sidewise sliding of the track shoes. If, referring to the figure, the tractor is turning in such a direction that the track roller on the right is coming out of the paper toward the reader, and the track roller on the left is receding, the resisting forces developed will be at the points adjacent to the small circles, in the directions indicated. These forces will reach their maximum when one track becomes blocked from turning by stones or stumps and the driver of the tractor at the same time applies the full power of the engine to the opposite track, in an effort to wrench the tractor free. In such a case the maximum forces *ff* which come against the lower ends of the arms *bb* will have the value pc/d, where p is the maximum tractive force developed by one track, c the tread of the tractor and d the distance between the roller bogeys.

The forces *ff* develop other forces on the ends of the springs in the directions indicated. In proportion to the lever arms the forces on the ends of the lower and shorter sections of the springs will be greatest and the forces on the ends of the upper and longer sections of the springs least. As the lesser forces therefore are on the longer ends of the springs, and the greater forces on the shorter ends, the bending moments at the spring-seats *aa* will be approximately equal and in opposite directions and therefore neutralize each other so that the resultant forces will consist of simple lateral loads at points *aa*. As no torsional stresses are applied to the springs, and as the lateral loads act on the spring leaves in the plane in which these are tremendously stiff, any tendency of the track rollers to move laterally, out of position, is rigidly resisted.

The spring-seats *aa* on both sides of the tractor are linked together by a rigid frame consisting of two steel castings on which the spring-seats *aa* pivot, and a framework of tubes brazed into these castings. This framework is supplemented by two cross-members which support the transmission, are bolted to the upper ends of the two castings referred to, and complete a box-truss construction of great rigidity.

The Frame and The Track Idlers

The main frame is of pressed steel and relatively light and flexible. It has no work to perform other than to carry the weight of the engine, radiator, rear axle and body, as it receives none of the twisting stresses developed in turning. The front idlers are of pressed-steel construction and run on roller bearings. They are not mounted directly on the front axle which is of tubing attached to the frame; but they are mounted on brackets which, in turn, pivot on this tubular front axle. These brackets are held in position between a stop and the quarter-elliptic spring which is attached to the side of the main frame.

When any track-laying tractor crosses a sharp ridge it will naturally, as soon as its center of gravity has passed over the crest, rock abruptly forward so that the front end will hit the ground a considerable blow. In this tractor this tendency is minimized by the spring suspension which compensates for inequalities of the ground to a considerable degree without causing the tractor to rock; but, in spite of this, the action spoken of will occur. The arrangement of the idlers described is such that the spring absorbs the shock of the blow. As the bracket is inclined at 30 deg. it tends to cushion both the shocks received from underneath the front idler and those received from directly ahead in cases where, for instance, the tractor runs into a tree or a wall.

As it is impossible to prevent stones and other foreign material from clogging and jamming between the track and the rear driving-sprocket, and as these would, unless prevented, produce frequently a tension in the track sufficient to cause breakage, it is necessary to provide some way of circumventing them. The front idler bracket and spring are designed to take care of this. As soon as the track tension reaches an excessive amount, it will pull the front idler upward and backward against the quarter-elliptic spring and the tension will thus be relieved. With this construction it is actually possible to throw common brick and sections of 2 x 4-in. wood between the track and the rear driving-sprocket without injury to the tractor, and in cases where a large amount of material becomes lodged between the driving-sprocket and the track, the former will turn freely without injury within the track.

It is evident that when the front idler bracket moves as a result of a blow on the front idler, and not as the result of the pull on the track, an excessive slackness of the track will be produced unless compensated for. Such compensation is necessary; otherwise the slackness would cause the track to jump over the flanges on the rollers and come off. The method of compensation is clearly shown in Fig. 3. As the bracket *a* moves around its pivot *b* the point *c* on this bracket swings through an arc and forces the compression member *d* upward and backward. This, in turn, acting on the link *e*, causes the track-roller supporting frame *f* to move upward and thus take up the slack created in the track.

When the movement of the front idler is due to excessive tension in the track caused by the jamming of stones, etc., this tendency of the track supporting frame *f* to take up the slack resulting from the motion of the front idler is not desired. The compensating member *d* is therefore made collapsible and held out at full length by internal coil springs adjusted to a predetermined tension, so that when the track tension exceeds a given figure, the compensating member will collapse and relieve the track tension.

As a further means of obtaining the essential flexibility and reducing the noise of the tractor at high speed, the front idlers and the track supporting rollers are provided with rubber tires ½ in. thick, these being molded on in the same manner that the ordinary truck tire is molded on its rim. The tires are very effective in reducing the noise of operation, and show no appreciable wear after 1000 miles of operation. The tractor will shortly be fitted with track rollers having rubber cores intended for the same purpose.

The track itself is made up of cast-steel links which are shown in Fig. 4. These links are designed so that they have a practically flat surface of small area bearing on hard ground, which will not injure good roads. In soft ground the links sink in until the cup-shaped surfaces at the side commence to bear, giving a much larger bearing area and a firm grip on the ground, tending largely to prevent slippage of the track. The smooth contour of the cup-shaped recesses makes them clear themselves of mud as they are lifted from the ground around the rear sprocket.

The shoe described is made of the lightest steel casting obtainable, as repeated tests have demonstrated that, other things being equal, a lighter shoe will outlast a heavier shoe of the same type. The explanation, which may seem strange to those who have considered steel

castings for static loads, is that an increase of section increases the weight of the shoe, and therefore its momentum, and consequently the shock loads it receives, more rapidly than the same increase of section increases the strength.

Twenty-four grouters are provided with the tractor for attachment to the track shoes when necessary; but it has been found that the shape used has been so effective in gripping soft ground, that grouters are necessary only in the very wettest marshes.

The Engine and the Transmission

The engine used is a White $4\frac{1}{4} \times 5\frac{3}{4}$-in. truck model. It was chosen because it delivers its maximum horsepower at a relatively high speed, which not only makes it a lighter engine than those having a slower normal speed, but permits the use of lighter power-transmitting parts. The engine was slightly modified in that the carbureter, magneto, wiring and other parts which might be affected by water, were enclosed in aluminum cases connected to a standpipe in such fashion that the tractor could travel through several feet of water without causing the engine to stall. In Fig. 5 the tractor is shown

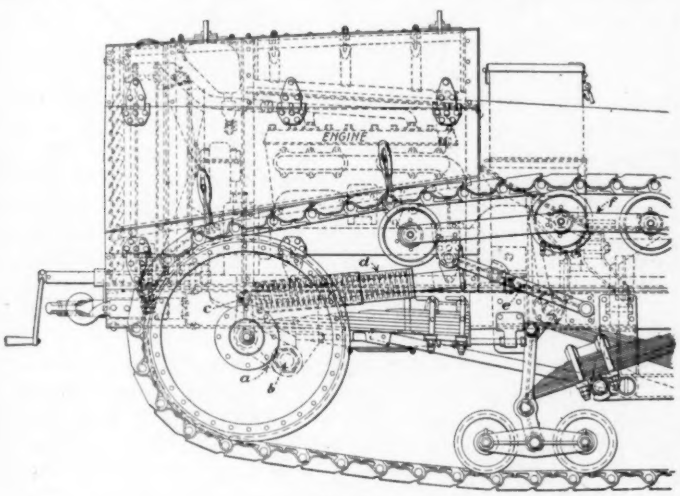


Fig. 3

crossing a ditch at Ottawa Beach and drawing a 75-mm. gun and its limber.

The choice of a transmission and steering mechanism was based on the experience that the average track-laying tractor has so much internal resistance that in using the conventional sliding type of transmission the tractor usually loses momentum and comes to a complete stop, or very nearly so, before the change in speeds is effected. This makes it necessary to be able to start the tractor on any gear on which it is decided to run. Starting on high gear requires a greater engine torque than if the shift to high gear is made while the tractor is in motion. The only known effective means to accomplish rapid speed-changes are differential gears and brakes or separate clutches for each speed. The last system was chosen because of its greater efficiency.

The drive from the engine enters the transmission through the couplings marked *a* in Fig. 6. The upper transmission-shaft is fixed to this coupling and carries the selective gears. By engaging the gears *b* and *c*, which are in different planes and so may not appear to mesh in the figure, the entire lower gearing is driven at one speed, and by engaging the gears *d* and *e* the same lower gears are driven at a different rate. These lower gears are arranged to drive the outer casings of four

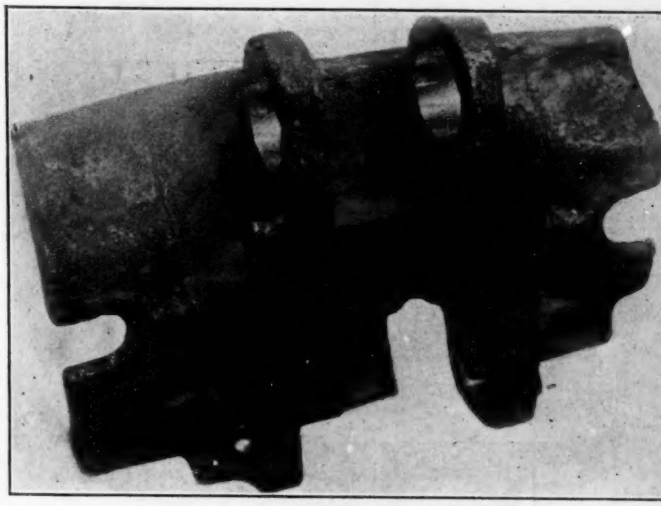


Fig. 4

Hele-Shaw clutches, two of which are mounted on each of the lower shafts. One clutch casing on each shaft is driven at high speed and the other at a lower rate. By engaging one or the other of the clutches on either shaft the drive is transmitted on the corresponding side at one of two speeds. There are thus two sets of speeds obtained by gearing and within each set there is a choice of two clutch speeds on each of the lower shafts, which gives a total of four forward speeds and two reverse speeds. To control the gears a gearshift lever of the ball-and-socket type is provided between the feet of the driver. The selective gears are shifted by the driver after releasing the clutch in the usual manner, but it is expected that he will not shift the gears except when the tractor is standing still. The low-gear speed is suitable for use when the tractor is traveling across country or pulling a heavy load. The high-gear speed is for use when running without load or over good roads. As long as the tractor remains on one class of service it is not necessary for the driver to touch the gearshift lever.

Brake and Clutch Controls

The only controls constantly used by the driver are two levers which project upward on either side of the transmission convenient for his right and left hands. These levers control the clutches and the brakes. When the levers are pulled back, the low-speed clutches, one on each of the lower shafts which connect through separate drives with the two tracks, are engaged and the tractor starts. When the levers are thrown forward the high-speed clutches on the lower shafts are engaged

Fig. 5

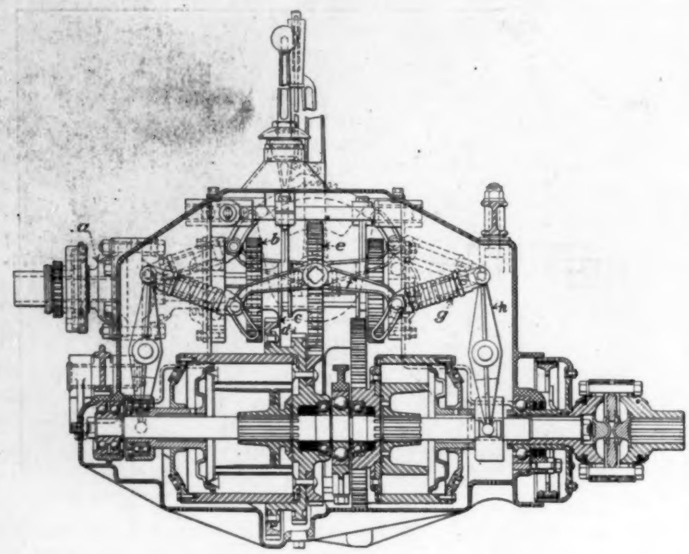


Fig. 6

and the tractor continues in high clutch speed. When the levers are pushed outward from their neutral position and then back, they engage the brakes which by pressing the thumb-knobs on the levers can be locked in position. In addition to handling changes of speed, the side control levers are used for steering, as this is accomplished by either driving the track on one side at high speed and the track on the other side at low speed, or by applying the brake to one track and driving the other. In this way the entire control of the tractor during normal operation is accomplished by these two levers and, the operation being readily learned, very little intelligence or skill is required to handle it.

The connection between the side control levers and the clutches is also shown in Fig. 6. One lever is rigidly fixed to the arm *f*. As this is moved in one direction it forms with the spring *g* a toggle which acts through the lever *h* on the clutch throw-out, in this case really throw-in, bearing and engages its clutch. With this arrangement a force of only 3 or 4 lb. on the levers is required to give the necessary load of 300 lb. on the clutches. As a result the operator can easily control

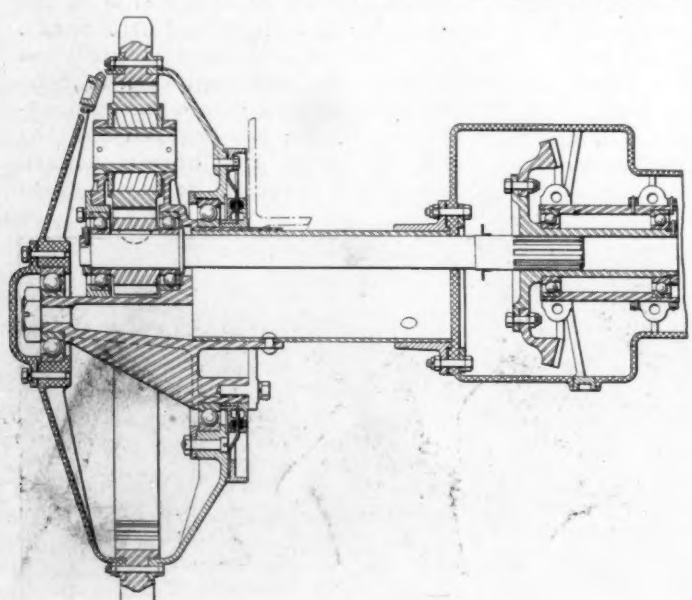


Fig. 7

the tractor with his two little fingers. The spring *g* is compressed to whatever load is desired on the clutches, in this case 300 lb., and irrespective of how hard the control lever is pushed or of what wear takes place, the actual load on the clutches does not depart from the predetermined figure. An allowance of 3/16 in. is provided for between the clutch plates without any manual adjustment, and when the wear has reached this figure, the pivot which is mounted on an eccentric can be shifted over and allowance made for 3/16-in. additional wear.

This transmission and steering clutch assembly combined requires only 10 gears to transmit four selective speeds on two separate shafts, or the same number that is required in standard four-speed transmissions driving only one shaft. As two of the clutches would be required in any case as steering clutches, the additional parts which must be charged against the advantage of having a highly flexible type of steering and speed control are the two extra clutches. This unit can be assembled and adjusted completely on the bench and placed in the tractor without further adjustment. The lower shafts carrying the clutches can likewise be assembled completely on the bench and can then be set into the transmission as a unit and capped in place. The direction of rotation of the gears has been arranged so that the resultant forces of the tangential and radial gearloads neutralize each other, with the result that little or no stress comes on the gearcase, which is made only strong enough to hold the weight of the parts. When the high-speed gear and the high-speed clutch are both engaged, the latter is rotating at a greater than engine speed. This was to reduce to the lowest minimum the torque which these clutches would have to withstand, and to permit the least weight in construction. In gearing up these high speeds it was inevitable that the pitch-line velocity of the gears would exceed the figure of 2500 ft. per min., which has heretofore been accepted as the maximum safe speed for gears transmitting power. It is the experience of the designers, however, that no sound reason exists for staying within this arbitrary figure, as on test a pair of these gears was run transmitting twice their normal horsepower at 8400 ft. per min. and the action was so smooth that there was no reason to expect undue wear. The first 1000 miles of operation of one of the tractors has failed to produce the slightest wear of the transmission gears themselves; nor has there been any sign of vibration resulting from the high pitch-line velocity which might affect other parts.

The transmission is suspended at three points from two cast-steel I-section cross-girders, one of the three points being on a pivot so that no cramping can result. The couplings between the transmission and the engine and between the transmission and each of the two driveshafts permit both angular and lateral displacements, so that considerable distortion of the main frame can occur without cramping the transmission.

The Driving-Axle

The driving-axle is shown in Fig. 7. It is of the internal-gear type with a separate pair of bevel gears and separate drives to each driving-sprocket. To make it possible to enclose the gears in such a fashion that dirt could not enter them and oil might not leak out, it was considered essential that the joint between the wheel and the axle be of as small a diameter as possible. Experience had shown that it is impossible to keep mud from entering the driving parts if the openings are on a large

diameter. For this reason the drive was brought into the wheel approximately on the center line of the wheel and transmitted to the internal gear by an idler. This is very similar to the arrangement used in the White truck axles and permitted the joint being placed on a small diameter where it could be effectually sealed by packing rings. The live drive-shaft used is placed slightly above the center line of the axle to raise the ring gears and increase the ground clearance. The driving-sprocket has been made integral with the internal gear, so that the sprocket covers, inside and out, receive no driving loads. The outer cover has no function other than to keep the mud out of the working parts and is therefore a light aluminum casting. The axle as a whole is rigidly fixed to the main frame by two U-brackets, one on either side. This is the only place at which the general rule to suspend all parts flexibly was not followed, and it is interesting to note that it was the only place at which failure occurred during the first 1000 miles run, the failure consisting in the cutting of the bolts which held the axle to the U-brackets.

Gasoline Tank Installation

The gasoline tank is mounted directly over the engine, partly with a view to placing it as far forward as possible, and partly to provide gravity feed to the carbureter. To protect the gasoline tank from the heat of the engine, a partition of asbestos covered with sheet steel is placed above the engine and 1 in. below the gasoline tank. This partition is arranged so that the slipstream line from the engine fan creates a continuous flow of air between the partition and the gasoline tank. This has the double effect of keeping the latter cool and of preventing any leakage from the tank dripping down on the engine and causing a fire.

All vital parts of the tractor, including the engine, radiator and gasoline tank, are protected by armorplate. This is assembled as a unit with the gasoline tank and can be easily lifted off by loosening four nuts and disconnecting the gasoline line to carbureter. When this unit is removed, the engine becomes readily accessible for repairs or adjustment. The body, consisting of the seats for the driver and the two extra men, is re-

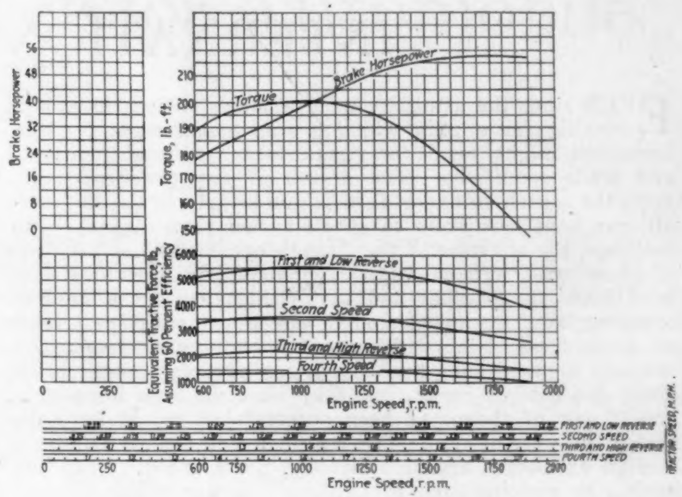


Fig. 8

movable by loosening four nuts; whereupon the transmission and rear-axle are easily reached for adjustment. The transmission and rear-axle can be detached by loosening a few retaining nuts on each. All the control levers are incorporated in the transmission unit so that no change of adjustment is required when the unit is placed in the tractor.

The tractor, when standing still, rests with its front idler touching the ground. In this position, however, it is so balanced that no appreciable load comes on the front idlers. As soon as the tractor is in motion, the front idlers lift up, with the result that the front portion of the track presents a gradual slope to the obstructions it meets, and the shocks resulting from them are reduced considerably. When pulling its maximum load the tractor inclines slightly backward.

The transmission ratios used and the operative characteristics of the tractor are set forth in Fig. 8. The curves showing the tractive force at different speeds were calculated on the assumption that the overall efficiency would be 60 per cent. Actual test results have given tractive forces and efficiencies in excess of the assumed figures.

COMING OF BRINE IN OIL WELLS

It is conceded by most geologists that petroleum was formed, under the influence of water, pressure and time, by the disintegration or slow distillation of the deposits of algae and minute animal organisms, accumulated millions of years ago in the shore waters of the sea. The remains of these plants and animals, together with mineral matter in a finely divided state, formed layers which, in the course of later geological periods, were buried under other layers. By the gradual uplift of the land mass the buried strata containing the remains of plant and animal life were raised above the level of the sea.

It is believed that under the great pressure of the superposed strata, the organic remains, in the presence of salt water and under exclusion of the air, were subjected to slow distillation or decomposition, possibly assisted by certain microorganisms. The products of disintegration, oil and gas, together with the absorbed sea water, were forced out of the shale and into adjoining strata of more or less consolidated sand, soft sandstone or similar porous material. There the water, oil and gas separated according to their specific gravity.

The salt water, being the heaviest, collected at the lowest level, above it the oil and above that the gas. If the strata had always remained in a horizontal position, the formation of pools or pockets of oil and gas in commercially valuable quantity would have been impossible. Only where the strata were folded by side pressure or locally raised in dome form by pressure from below, were the conditions favorable for the forming of oil or gas pools.

When an oil well is drilled until it reaches the oil-bearing sand, the oil will be forced up through the pipe by the pressure of the gas and the hydrostatic pressure of the water. It will form a gusher and continue to flow with diminishing force until the supply of oil is exhausted or it is drowned out by the encroaching salt water. As the oil recedes under diminishing pressure, the level of the brine rises until it reaches the intake of the well. The invasion by the salt water is accelerated on account of the pressure to which the brine is subjected as a result of the accumulation of gas in the adjoining fold.

The coming-in of the brine invariably means the end of a well's productivity. Sometimes if the well is closed for a while, an increase in the gas pressure may cause the water to recede for a short time, thus prolonging the life of the well, but with a greatly diminished yield.—E. Welleck in *Popular Science Monthly*.

INTERNATIONAL EXCHANGE

EVER since the armistice men of many nations have been seeking for a plan which it was hoped when put into operation might result in reestablishing normal industrial and trade conditions. The dearth of any practical result from the search so undertaken is due largely to the fact that all eyes have been fixed on effects rather than causes. For instance, the question of the foreign exchanges has been one of those most written and talked about. Suggestions have been made in speeches and in writings as to the need of bringing back the exchanges to par or of stabilizing them at some fixed points. Plans without number have been brought forward that the originators have felt might bring about the desired result, but they have all been impossible, and if any of them had been successful it would have defeated the ends desired. The reason lies in the fact that the foreign exchanges are an effect and not a cause. They can neither be stabilized nor brought back to par unless the conditions which caused them can be remedied or nullified.

When the British Government during the war stabilized sterling exchange in New York at 4.70 to the pound, it was able to do so only because it was in position to purchase all the sterling exchange that was in the market at 4.70 a pound which could not be absorbed by commerce or other requirements for sterling and at the same time was able to sell sterling exchange on such days as the demand exceeded the supply when the rate naturally might have gone above 4.70 to the pound.

Any of the foreign exchanges today could be stabilized in the same manner and at any fixed rate, par or other point, that might be determined upon, provided any government which desired to accomplish such a result with its exchange on any country or series of countries was in position to obtain the foreign monies necessary to take up any surplus which might be offered, and could in effect sell its own exchange in the foreign markets when required. If, as between any European country and the United States for instance, the European government should determine to stabilize its exchange and, for the sake of illustration, no other countries were involved, it could be done provided such European country could export to the United States values equal to the imports from the United States, accepting for the moment the thought that exports and imports cover capital as well as commodities. If instead of such country being able to find an equivalent value of its imports from the United States for export to the United States it could only find half of such value, it could still maintain the exchange at a fixed point for just as long a time as it could borrow the difference in the United States. Should the European government continue to borrow in the United States every year for an extended period sufficient to make up half the total of its imports, each year it would be obliged to borrow more in the United States by the amount of interest which it had to pay on its loans in America. Of necessity, therefore, a time would come when the interest on the debt which the European government owed the United States would exceed the value of its exports to the United States. As soon as this point was reached, and taking it for granted for the sake of illustration, that the exports and imports between this country and the United States ran in the same totals year in and year out, a situation of bankruptcy would have been developed as between such country and the United States. After the interest which it had to pay exceeded the total value of its exports it could never pay the principal, even though it should stop all importations from the United States.

Now, if such a country of necessity was obliged to import from the United States certain things amounting to a large proportion of its ability to export, its position of bankruptcy would be realized when the interest which it owed to the United States exceeded the difference between the value of its exports to the United States and its imports from the United States. Even, therefore, if such a country could borrow in the United States for a series of years a sufficient amount to offset the difference between its exports and imports and the interest which accrued, it would inevitably be approaching a time of bankruptcy when its imports from the United States would have to stop. Should a European government undertake such an operation there would be nothing to prevent her people from importing anything and everything from the United States that they might desire as long as the exchange was so stabilized, regardless of whether such things were needed or not. On the other side, there would be no particular incentive for its people to increase their exports to the United States, and the cause of the trouble would continue even though the effect, because of loans, was not noticeable in the exchange.

Under such conditions the operation as it would affect the United States would simply be one where those who purchased the European government securities would, in effect, be buying the commodities exported to such country from American manufacturers and producers, paying for them with dollars, but without having any use from them. Should the American Government make the loans to the European government instead of individuals, the United States would be in a position where the tax payers were in effect buying goods from export manufacturers and producers which they never received. Regardless of the wealth of a country, an operation of this sort could only last for a limited time on the basis of our present European trade, and the waste to the United States would be equivalent to war waste insofar as reducing the wealth of the nation was concerned.

There is no question, therefore, but that the mere stabilization of the foreign exchanges as they exist today would be most harmful to the world and would only postpone the present difficulties until a later date when all chances of recovery would have passed. Any plan, therefore, aimed to correct the exchanges which does not correct the causes for their disorganization is almost certain to result in financial disaster.

We are therefore thrown back upon the causes for the condition of the exchanges, and the problem is seen to lie wholly in finding a means of eliminating such causes. Before we can do this, however, it is necessary to understand the causes. This is not difficult. For five years practically all production throughout the entire world has been to meet the necessities of the people for existence, meaning prompt consumption, and then for purposes of war, also meaning prompt consumption or destruction. In all the neutral nations of Europe the depletion of goods ordinarily desired by the people has been as great as was true with the warring nations. This resulted from several causes, the two principal ones being the high prices which the necessity of those at war made them willing to pay for quick delivery, and the disorganization of the shipping of the world.—F. I. Kent.

RAILROAD ELECTRIFICATION

ELECTRIFICATION has won its way for the Chicago, Milwaukee and St. Paul Railway in various economies by eliminating the necessity of hauling coal in a tender for each steam locomotive; it has not only tremendously reduced the coal consumption of the railroad, but has increased the ton-mileage by approximately 8 per cent on the mountain divisions. The greater power of the electric locomotives, as demonstrated daily in actual service as well as in the more spectacular tests of strength with steam locomotives in which the latter have come out second best, has practically doubled the ton-mileage of the three electrified divisions with no increase in trackage beyond that incident to the normal development of the railroad, and with a great reduction in the number of locomotives, instead of the increase which would have been necessary under steam operation.—*Transportation World.*

The Most Suitable Steels for Automobile Parts[1]

By Dr. W. H. Hatfield[2]

After careful consideration, the following steels, selected from the British Engineering Standards Association's specifications for wrought automobile steels, were considered to be capable of supplying, with few exceptions, the wants of the automobile and airplane constructor, whether he be producing (*a*) airplanes, etc., (*b*) touring and racing cars, or (*c*) slow-moving vehicles. The selected steels may be enumerated as follows:

(1) 40-ton carbon steel
(2) 0.10 per cent carbon case-hardening steel
(3) 5 per cent nickel case-hardening steel
(4) Nickel-chromium air-hardening steel
(5) 3 per cent nickel steel
(6) 3 per cent nickel-chromium steel

I also consider three or four more steels as being of sufficient importance to the industry to merit careful consideration, along with the six mentioned above. These steels are

(1) Chromium-vanadium steel for general purposes
(2) Spring steels
(3) 12 to 14 per cent chromium steel
(4) 0.9 per cent chromium steel

The Selected Steels

The 40-ton steel is preferably an acid Siemens steel containing about 0.45 per cent carbon. The manganese content, which exerts a very important influence upon the mechanical properties, should be approximately 0.6 to 0.8 per cent. The steel should not be put to work in the forged condition, but should be normalized by heating to a temperature of 850 deg. cent. (1562 deg. fahr.) soaking through at that temperature and allowing it to cool in air away from drafts.

Owing to its peculiar adaptability for clutch-plates, keys, etc., the 0.9 to 1.0 per cent carbon steel is included, and as before stated, is favored for piston-pins. It may be produced either by the Siemens, electric or the crucible process.

In my opinion case-hardening of steels will always have considerable importance in aeronautic and automobile engineering, owing to the fact that in numerous instances local and surface hardness is required, combined with the essential toughness in the part as a whole. These steels are particularly interesting owing to the fact that there is little difficulty at any rate in the nickel case-hardening steels, in inducing into the part as a whole mechanical properties which are comparable to those of the high-tensile steels.

The 0.10 per cent carbon case-hardening steel, and the 5 per cent nickel case-hardening steel have been selected, to the exclusion of others since it is felt that if there is any need to improve on the mechanical strength obtained in the case of 0.10 per cent carbon case-hardening steel, the best thing to do is to proceed immediately to the 5 per cent nickel steel.

In comparing the properties of the carbon case-hardening steel with the 5 per cent nickel steel, the essential difference noted is that the mechanical strength of the core of the nickel steel is very much greater than that of the carbon steel, although the actual hardness of the hard surface produced on the carbon case-hardening steel is a little greater than the hardness of the hard surface produced by carburizing on the 5 per cent nickel steel. This difference in hardness is, however, small and, except in very special instances, is of little importance compared with the great increase in mechanical strength induced by the presence of the nickel.

Air-hardening nickel-chromium steel is used largely for gears, although it is considered that the mechanical properties of the material are such that time and a more complete understanding of the steel will lead to its more extended adoption for many other parts. Essentially it consists of a 0.30 per cent carbon steel to which has been added slightly more than 4 per cent of nickel and about 1½ per cent of chromium. The final treatment consists of heating uniformly to a temperature of 810 to 820 deg. cent. (1490 to 1508 deg. fahr.) followed by cooling in air away from drafts. Unless the heating is perfectly uniform, and the cooling is conducted in such a way that the part cools equally, distortion is likely to result. The practical experience of many people has, however, resulted in a gradually increased use of this material. After the air-hardening operation, it is advantageous to reheat to temperatures of 200 to 250 deg. cent. (392 to 482 deg. fahr.) which has the advantage of eliminating any stresses left in by the air-hardening treatment.

The 3 per cent nickel steel requires little comment. I would, however, observe that it should be hardened and tempered if the best mechanical properties are to be obtained. If hardened and tempered the result is a high-tensile steel with maximum ductility. This steel is safe to use and is less likely to suffer materially in mechanical properties, through inaccurate treatment, than some of the other alloy steels.

The 3 per cent nickel-chromium steel is practically the preceding to which has been added 0.5 to 1.0 per cent of chromium. This addition produces a steel which hardens more effectively, which, of course, means that parts of thicker section are most usefully made in it, since hardness through the mass is more easily obtained than in the absence of chromium.

The Alternative Steels

There has been much discussion on the merits of chromium-vanadium steels but I am thoroughly satisfied that the chromium-vanadium steel and some of the chromium steels are well worthy of careful attention from the industry. For rear axles, propeller-shafts, transmission shafting, etc., chromium-vanadium steels have given very satisfactory service, and for that reason it would be unwise not to give them sufficient prominence in this work. It is believed to be a fact that these chromium-vanadium steels have earned their present reputation chiefly through the almost entire absence of failures in parts produced from this material.

The "stainless" and non-rusting properties of the 12 to 14 per cent chromium steel coupled with its high mechani-

[1]From a paper read at a meeting of the Institution of Automobile Engineers, London.
[2]Brown-Firth Research Laboratory, Sheffield, England.

cal properties, lead me to suppose that its use in the aeronautic and automobile industries will be limited only by economic considerations. There are undoubtedly many parts for which it is admirably suited. The essential thing to remember is that the steel must be hardened and tempered if its available properties are to be obtained.

Valves and Springs

The valve problem is the one which, perhaps, gives the greatest scope to the metallurgist. The steel employed must have good mechanical properties, but must also maintain its strength at high temperatures. Exhaust valves have to withstand temperatures from 200 deg. cent. (392 deg. fahr.) up to well above the critical point while inlet valves have also to stand high temperatures; in some cases high enough to weaken many steels seriously. The steels which best resist a diminution of strength with an increase in temperature are high-tungsten and high-chromium steels.

The 12 to 14 per cent chromium steel is recommended for high-temperature work. A considerable amount of experience has indicated that this material is adequate for the work, and it has the further advantage of being less expensive than the tungsten steel. Where temperatures are not so high, the 3 per cent nickel steel and in some cases low-carbon steels may be, and are, satisfactorily employed.

In discussing springs we have two essential types to consider (*a*) valve springs and (*b*) bearing springs. I have had a great amount of experience in this particular field, and have no hesitation in recommending chromium-vanadium steel for valve springs. Actual service conditions have shown that this material in a suitably hardened and tempered condition, gives excellent service.

For bearing springs there are two steels which adequately meet the case, namely, chromium-vanadium and silico-manganese steels. What is wanted in a spring is a very high elastic range, accompanied by a freedom from intrinsic brittleness.

Steel and Iron Castings

It will be remembered that, early in the war, L. H. Pomeroy read an extremely interesting paper, in which he lamented the fact that the country could not supply its own requirements in small steel castings for automobile work. There are several British firms who are now actively engaged in this field. Small castings can be made of steel of excellent mechanical properties, and the material is an extremely desirable one for such parts as rear-axle castings, fan centers, spring brackets, differential casings, cylinders, gearboxes, axleworm cases, wheels, pistons, axle-jaws, frame-members, etc. The bulk of the steel castings for such purposes run from 0.10 to 0.30 per cent carbon and should be low in sulphur and phosphorus.

It is unnecessary to confine the composition to that which is largely employed, as steels of various compositions, including the special steels, can be effectively cast but, of course, require special knowledge and treatment.

Malleable castings are used to a great extent in the automobile industry both at home and abroad, particularly abroad. This material has mechanical properties much superior to ordinary cast iron, and for many parts constitutes really an excellent material. Like all other cast parts, however, the principal difficulty lies in the fact that the castings are not always free from mechanical defects. In the best managed foundries these faults may be and are entirely overcome. There are two kinds of malleable castings: the Reaumur, or European material, and the American or "black heart."

Cast iron is not used for many parts, its main application being in the cylinder, pistons and piston-rings. Like all the other materials discussed so far, cast iron is worthy of very careful study, and the engineer would be well repaid in controlling the analysis in certain essentials and in having mechanical check-tests particularly so in view of the fundamental importance of the parts just mentioned. Analysis, dimensions of section and the casting temperature are the main factors which determine the ultimate mechanical properties of the material.

As regards the mechanical properties of cast iron, it may be assumed that a good cast iron in automobile castings will have a tensile strength of 14 to 16 tons per sq. in. accompanied by a yield which synchronizes with the maximum stress with a complete absence of ductility; at any rate, as far as all practical considerations are concerned.

Conclusions

Working on the assumption that there is a best condition of some particular steel which will enable a particular part to fulfill the function for which it is intended, I have made a definite choice of material for each of the more important parts of touring and racing cars which is given below.

Air-hardening Nickel-Chromium Steel—Connecting-rods, transmission gears and steering worms, pinions and pivots
Aluminum Alloys—Cylinders, pistons, crankcases, gearboxes, axle-casings and differential casings
Bright Drawn Mild Steel—All nuts
Case-Hardening Carbon Steel—Ball races
Cast Iron—Water-cooled cylinders, cylinder-liners, valve-guides, valve-seats, water-jackets, pistons, piston-rings and inlet and exhaust pipes, including manifolds
0.9 *Per Cent Carbon Steel*—Clutch-plates and keys
40-*ton Carbon Steel*—Internal and external cone-clutches, dumb-irons and rear-axle housings
Chromium-Vanadium Steel—Valves, clutch and chassis springs
High-Carbon Chromium Steel—Ball bearings
Malleable Cast Iron—Inlet and exhaust pipes, including manifolds
3 *Per Cent Nickel Steel*—Front wheel stubs, steering-arm levers, arms and rods, tubular steering columns, steering swivel forks, chassis frames, front and rear axles and torque tubes
5 *Per Cent Nickel Case-Hardening Steel*—Piston pins, valve cams, camshafts, tappets, timing wheels, differential spiders, gearbox shafts and transmission worms and worm shafts
3 *Per Cent Nickel-Chromium Steel*—Connecting-rods, crankshafts and clutch-shafts
Phosphor Bronze—Worm wheels
Silico-Manganese Steel—Valves, rotary pump gears and wire spokes
40-*ton Steel*—Cylinders, brake drums, shoes, thrust and clutch withdrawal collars, differential gearboxes, front and rear wheel stubs and spring shackles
Pressed Steel—Axle castings and differential casings

It will be found that an arbitrary selection of materials has been made practically within the specifications drawn up by the Steels Committee of the Institution. It must, however, be reiterated, as stated earlier in the paper, that those specifications do not by any means include all the steels which can be used with advantage in automobile engineering. Particularly is it noticeable that the chromium-vanadium steels are excluded from the specifications. I merely cite this steel as indicative of the fact that there are now, and probably in the future will be, still more useful steels.

RELATION OF TRACTOR WEIGHT TO PULL

WITH the engine generating power sufficient to slip the wheels or tracks, the drawbar-pull which it is possible to obtain with any given tractor is limited by the tractive effort that the ground will sustain and is influenced by the efficiency of the wheel or track equipment. There are two ways of securing traction. The weight may be so great that the friction between the ground and a smooth surface will furnish all the pull required, or the influence of weight may be augmented by the use of lugs or cleats. Relying upon weight alone would result in too heavy machines.

By using lugs the shearing strength of the soil is brought into play, which in most cases is greater than the friction between the earth and a smooth steel surface, such as is afforded by the surface of the rims. So far as is known, there are no data available to show the increased traction which it is possible to secure through the use of lugs, but fortunately the results of field experience are so conclusive on this point that lugs are usually recognized as standard equipment on all wheel and some tracklaying machines. From the practical standpoint we are not especially interested in the results that might be obtained without the use of lugs, but it is important to know what percentage of the total weight can be delivered at the drawbar when lugs are used. This will depend upon conditions. A firm clay surface will give better results than one soft and spongy. The type of lug, distribution of weight and rate of travel also will have effects. Unfortunately there are not sufficient data available to permit the developing of general laws showing how each one of these factors affects the problem. There are, however, some data available from which facts can be gathered showing what results have been attained with representative machines.

At the Lincoln, England, tractor trials 20 four-wheeled machines were tested on a heavy clay clover land in wet condition. No information is available regarding the lug equipment or rates of travel. The results are given in Table 1. From these figures it appears that these 20 machines were able to exert a drawbar-pull on the average equal to 50.19 per cent of their weights, with a maximum of 67.60 per cent and a minimum of 30.40 per cent. It is interesting to note that the average pull exerted when skidding the wheels was equal to 64.14 per cent of the weight, while the maximum was 92.40 per cent. These figures are of value as showing the maximum which it is possible to obtain under the conditions of this test.

Of special significance are the figures showing the relation between drawbar-pull and weight on the drive-wheels. It is well known that the weight on these drive-wheels is greater when the machine is operating than when standing still, as reported, but even making due allowance for this fact, 93.08 per cent of the weight on the rear wheels in drawbar-pull is remarkable for average performance, while the maximum

TABLE 1. DATA FROM THE LINCOLN, ENGLAND, TRACTOR TESTS

	Maximum	Minimum	Average
Percentage of total weight to drawbar-pull, plowing	67.60	30.40	50.19
Percentage of total weight on drive-wheels	79.40	57.10	68.97
Percentage of total weight to drawbar-pull required to skid wheels	92.40	41.10	64.16
Percentage of weight on drive-wheels to drawbar-pull required to skid wheels	132.50	62.50	93.08
Percentage of weight on drive-wheels to drawbar-pull, plowing	90.00	52.50	72.66

132.50 per cent indicates that with proper lug equipment it is possible to secure excellent performance in this respect. The variation reported would indicate that lugs have a very marked effect in determining just how large a percentage of the weight on the drive-wheels can be delivered as drawbar-pull, even making due allowance for the differences which may have existed in the hitch and rates of travel.

The data reported from the Ohio field tests in Table 2 are not as complete as those given for the English trials. They do, however, furnish an opportunity to compare the performances of the same machines when operated on different surfaces. These figures are taken from the maximum tests and show that the character of the surface has a marked effect.

On the average the performances of the two tracklaying machines in all four tests are better than the eight wheeled machines at Akron and Columbus and twelve outfits of the latter type at Fostoria and Middletown, as would be expected, because their entire weight rests on the driving-tracks. Perhaps the most striking fact revealed by these figures is the wide variation in the results obtained by various machines, indicating that there is need for investigation work on this subject to develop the fundamental laws governing the design and use of lugs. It may be a happy accident that mechanical features have been so combined that one particular wheeled machine was able to deliver over 70 per cent of its weight at the drawbar in two tests and a tracklayer 77.5 and 70.1 per cent in the same tests, but I think not. Rather it shows the results possible to secure by the proper distribution of the weight, lug equipment and hitch, and serves to focus our attention on the possibilities in this direction, especially when the average performance is 50 per cent or less.—E. A. White in *Farm Implement News*.

TABLE 2. PERCENTAGE OF TOTAL WEIGHT DELIVERED IN DRAWBAR-PULL UNDER VARIOUS CONDITIONS

Place of Test, Kind of Soil	Akron Sandy loam, dry, hard	Columbus Clay loam, dry, hard	Fostoria Heavy loam, dry	Middletown Sandy loam, wet surface
Wheel Machines				
Maximum	59.00	62.50	70.50	70.80
Minimum	26.00	33.00	34.00	26.30
Average	44.07	46.20	50.20	40.00
Tracklaying Machines				
Maximum	53.50	60.00	77.50	70.10
Minimum	33.10	50.00	44.60	35.00
Average	43.30	55.00	61.00	52.70

FEDERAL AIR REGULATIONS IMPORTANT

THE future of aeronautics is bound up inseparably with its safety. Builders of airplanes and airplane engines have for years struggled doggedly to make flying safe, yet despite the tremendous progress they have made they have not entirely succeeded. In a recent interview with Frederick B. Rentschler, general manager of the Wright Aeronautical Corporation, the fact was brought out that the reason why manufacturers have not succeeded in making flying safe despite the progress made is because it does not lie within the power of the manufacturer to make flying absolutely safe. He stated, "There is another element in the solution of the problem and so far this element has been as backward as the manufacturers have been progressive." That element is the promotion of landing fields, the assurance of the competence of pilots and the institution of proper inspection and regulation of aircraft in commercial or private use.

It is no more within the power of the aircraft builder to institute a national system of good landing fields than it was within the power of the automobile builder to construct a national system of good roads. It is no more within their power to control those who fly airplanes than it was in the power of the early locomotive builders to compel the railroads to employ competent engineers. Neither is it within their power to insure the proper inspection and regulation of aircraft than it was within the power of shipbuilders to establish the present system of marine inspection and regulation of steamships.

After a careful study of the causes of the comparatively few casualties in aviation it can be said without hesitation that these three things would have reduced accidents to a negligible quantity, to a point where they would appear startlingly low in comparison with automobile fatalities. The number of pedestrians killed by automobiles in New York state for the month of June amounted to 184. The reason why airplane accidents cause more stir is that automobile accidents are too common to have much news value while airplane accidents are considered much more interesting and in most cases are extraordinary and accordingly are "played up" in the newspapers.

The matter is pressing. Already in Great Britain and other European countries landing fields have been established and laws of the air formulated. America taught Europe how to fly, but Europe is teaching America how to utilize flying. In this country some progressive communities have founded landing fields and some cities have adopted airplane laws. The manufacturers are always glad to hear news of the establishment of new landing fields, whether they are established by cities, States or private individuals, but all face the danger of a heterogeneous mass of local ordinances which will hinder rather than help aviation. Only Federal laws like those controlling railroads and steamships can prevent many conflicting local laws, for cities and towns everywhere are either demanding or already formulating air codes.

Men of public affairs and the public generally still think of aviation as a thing of the future or an instrument of war. This is a serious mistake. Aviation is already here in everyday life. Little signs of this are daily bobbing up in print. The recent college meet, the carrying of 2000 lb. of grape fruit 1500 miles up the Atlantic coast from Miami to New York by flying boats because of the freight congestion, the commuting of 10 prominent New York bankers to their homes at Southampton, Long Island, by aerial cruiser, the successful air mail routes, the start of the New York to Nome, Alaska, flight by the Air Service; all these things show plainly that practical aviation is here.

Although aviation is here, it is here in a very modest way in comparison with its undoubted future. The bringing nearer of that future of vast importance is a matter in which our government must cooperate. Once the people realize that flying is actually here for "keeps" there is but little doubt that we will secure our needed regulations, licenses and landing fields.

Cities, too, will realize that air harbors are as important as seaports and will make haste to establish them lest they be passed over by the great aerial freighters and liners in favor of more progressive and more hospitable municipalities.

That is, briefly, the peace angle of the aerial proposition. As far as war is concerned, a close-linked union between airplane and engine manufacturers and the government is even more necessary. It is vastly more economical to establish landing fields and formulate regulations now than to endeavor to raise an industry over night by the brute power of vast sums of money poured out on the eve or after the outbreak of war.

Concerning this Mr. Rentschler said, "I can speak authoritatively from a production point of view. We had to start at the very bottom in April, 1917, and although we developed production from four engines monthly in 1917 to 1000 engines monthly 16 months later, that period of desperate effort to get the factory actually running might be the period in which a wiser enemy who had fostered flying could strike and win. Among the difficulties we had to overcome was to get a foundry running for aluminum castings and parts, and to train 8500 men and women, not 20 of whom had even touched an aeronautic engine, to make airplane engines quickly and well. Although we are proud of that production record we do not want to be compelled to go through it again in the next war.

"Let us, if we are ever unfortunate enough to face an enemy in the future, do so with a highly productive, scientific, 100 per cent American aviation industry in full blast capable of producing both airplanes, engines and airships, accessories, etc., at the rate of production automobiles are made today. We can only be thus prepared by keeping abreast of the times in the field of commercial flying."—Air Service News Letter.

ADDRESSES OF MEMBERS DESIRED

AT the present time the records of the Society do not contain the correct address of each of the members listed below. In every case communications sent to the last known business connection or mail address as it appears on the records has been returned to the New York office of the Society. Members who can supply information regarding the present location of these members or offer any suggestions as to where their correct addresses can be obtained will confer a favor upon the Society by communicating with the Secretary at the New York office. Any information that can be furnished will be a favor conferred upon the Society since it is only by the cooperation of the entire membership that the mailing list can be kept in an accurate condition and the members receive THE JOURNAL and other communications promptly.

BARKER, GEORGE R.
BONNEY, W. L.
CHADBOURN, H. N., JR.
GOLDMAN, J. M.
GREEN, L. P.
HARDING, HERBERT P.
JEROME, H. M.
JOHNSON, A.
LEWIS, WILL I.
LUMENT, GEORGES
LUZIUS, WILLIAM CHARLES
MCMILLAN, HORATIO G.
MILLER, JAMES A.
ROSS, JAMES
SCHMIDT, HUGO F.
SINK, RUSSELL S.
SMITH, EDWIN M.
THEISEN, ALEX. J.
TUCKER, GORDON E.

The Engineer in Industry

By EDWARD A. DEEDS[1]

INDIANA SECTION ADDRESS

THE war is over. I think that one who has been two years away from his own business gets different impressions than do those who have been following their business during the war. There has been a great change. We have had an awakening in this country such as we never had before. I do not know that we have had the awakening we should have had, but I believe that we have not gotten out of the war all that we should. The war ended too soon. I do not want to be misunderstood. The war did not end a day too early for those boys who were making the sacrifice on the other side. But I recall vividly what one of the French officers said to me in Washington. It was a privilege to sit beside men from England, France and Italy, assigned by their Governments to duty over here. We found these men deadly in earnest because to them the war was the real thing. If the German army had been at Richmond, coming toward Indianapolis, it would have been a very real thing to you. If it had been in Cincinnati, coming toward Dayton, we would have looked at the thing in a very different light. The French officer mentioned said to me with tears in his eyes, when the time came for him to depart for the other side, that he hoped we would get out of the war what we should, but that he thought the war had ended too soon for the United States, that if the casualty list had been longer it would have brought home to every village and hamlet the reality of the awful situation, so that some of the selfishness would be wiped out and some of the bigger things that war ought to bring to us would come to our country. He said: "God forbid that the United States should suffer as France has suffered, because the best blood of France has gone." This put a somewhat different aspect on the whole matter. We could not help coming back to our business with a different view after hearing such sentiment from the friends who were with us. Things are not as they were before. The lines we had projected do not meet now. The guns we had set up do not seem to hit the target; either the target has moved or the gun is too short-ranged.

LABOR QUESTION

The first thing I ran into, naturally, when I returned to our factory was the payroll sheet. Something had certainly happened to that in the last two years. I had never seen such expansion. I do not know what lesson we are to draw from it. I think that the greatest questions before this country today are the wage question and the relations between capital and labor. They alone can prevent us from moving ahead in an unlimited way. I think that those of us who are employers will have to modify our views. I know that the laboring man must modify his present views. I think that the shorter hours are here to stay and that the high wages are here for a long time. I do not know but that they should be. Many of these things will have to be worked out in a different way. I think, on the other hand, that labor will have to realize that there is a limit which it cannot pass, and that increased production is necessary.

The labor question need not disturb us greatly, because the good commonsense on both sides will finally prevail; the radical element is not going to dominate on either side. The red flag and bolshevism are not going to get very far here as long as a boy has the opportunity that he has in this country. I look ahead with a great deal of optimism with reference to this whole labor problem.

If we can reduce the high cost of living, much of this labor unrest will be eliminated. That is going to come finally. There are many causes for the high cost of living. When I used to go to the grocery store for a little vinegar, mother would give me a jug, the groceryman would go down into the cellar and get me 10 cents' worth, and I would walk back home with it. That is not the way we do it now. The servant, who gets a pretty good salary, not wages, uses an expensive telephone and says, "I want such-and-such special brew of wine vinegar." It is delivered after awhile in a finely painted automobile, with a chauffeur and a footman in uniform, and the footman carries the vinegar up to your door in a glass bottle as if it were toilet water. This is that same poor little 10 cents' worth of vinegar, and it has to carry all the overhead expense indicated. As long as this sort of thing exists, the high cost of living will exist.

Another thing is the income tax. Most of us will admit that the large individual incomes should carry a good heavy tax; we are all broad-minded enough to think that. But the corporation income tax should be modified so that our business can move ahead more rapidly. If it were cut in two, we would get as much revenue or enough.

We are being led into extravagant expansion and permanent improvements that we do not need. These lead to higher cost of production. I believe that few throughout this country realize what this means. The 20-cent dollars, which you charge out as 20 cents when you come to add them to the price of your commodity, whether it is an automobile or something else, go back as 100-cent dollars.

NECESSITY FOR INCREASED PRODUCTION

The really fundamental thing, the thing that concerns engineers, outside of our exorbitant desires and increased requirements and corporate extravagances, is lack of production. We are not doing enough individually. Our individual production is going down, and as long as it continues to go down the prices of things are bound to be up. We do not begin to produce the things we want. This summer I took an automobile trip out through the West. We had sleeping bags, slept outdoors in the mountains and had a wonderful experience. Out on those ranches we found that their requirements were not very great and they could produce what they demanded. But if you go to a city you will find that you cannot begin to produce the things you need. How long would it take one of us to make a pattern and cast a bath-tub? We would be about a year making one bath-tub, and by the time we could complete a kitchen stove and build our house with our own hands we would be ready to die. The only way we do these things is by higher organization and better systems of production. The only way we can meet this whole situation is to bring up production. The laboring man must think of this because, unless he

[1]M. S. A. E.—President, Domestic Engineering Co., Dayton, Ohio.

is willing, along with his demands and his wages, to bring production up commensurately, he is not going to help his situation with regard to the price of the things he uses. We must have more production per capita, by hand or by machinery. We are several years behind on account of the war. Germany is making plans to go right ahead industrially as she never has before. The laboring people there are planning to put in more hours, if necessary, to bring up their production. We have a real problem to face if we are going to meet Germany commercially, just as soon as she gets started in this field. We must realize that her position is very different from that of France or England. Germany has no external debt of any consequence. She is awake. Her factories are intact. We find things there not disturbed at all; business is going on and is in better shape to go ahead with foreign trade than it is in this country today. That ought to be an eye-opener to us here.

All of these things should not disturb us. What we want now is plenty of optimism and a lot of confidence in this big country of ours. I wish all of you could go up in an airplane as I do once in a while and ride around over cities and country and see how wonderfully beautiful this country is. I believe that even with our large ideas of industry we can never measure up to the requirements of this country. But if everybody keeps his feet on the ground and forges ahead with a lot of good commonsense, there is no reason why we should not have progress in this country. We must, however, grasp the bigger things and quit fooling with the little things. The wise manufacturer of today will have confidence and enthusiasm to move right ahead, be conservative enough to not over-expand and, looking ahead five or ten years, have his factory in shape to meet what may come later on. I look to the future with a great deal of confidence.

I would like to bring a message to the engineers tonight. There never has been in the history of the world such an awakening along engineering and research lines as we have had in this country in the last two years. We realize as never before what the research engineer means. It was not the German army that bothered us. The laboratories and the research engineers of Germany held the whole world at bay and very nearly won against all of us. I think we all soberly realize that now. I am sure that those of us who were close to the seat of war realize it. We had not been awake to some of these things as we should have been. I hope there has been a thorough awakening all along the line.

There has been a sudden desire on the part of the young people of this country to get a better education. That goes to show that the experiences we have had in the last two years have stirred us to the realization of the necessity of knowing more. It is one of the good signs and carries with it a lot of opportunity, as well as considerable responsibility. We must never lose the impetus we have attained. The next twenty-five years will be the biggest twenty-five years, industrially and from a scientific standpoint, that this country has ever had. More new things are going to be developed and done in the next twenty-five years than have been done in the last hundred years. And, if you check up the things done in the last hundred years, you will find that most of the modern things upon which we depend were developed in that period. There is no doubt in my mind that this is the pace set for us, and we must realize that every other country engaged in the world war had an experience similar to our own. We must move ahead. The engineer must do his part. America certainly must not lag.

Aircraft Development

It is only fifteen years since the Wright boys, in their little bicycle factory, were making their flying machine. Everybody thought they were crazy and nobody would go out to see their machine fly. Three years ago the only flying machine we had in this country was a training plane, with an 80-hp. engine, that would go 50 to 60 m.p.h. Then we would not have thought of starting from Indianapolis for Dayton by airplane. Today flights from coast to coast are being made. Two days ago a man started from Mineola, Long Island, landed in Chicago the first day and at Cheyenne the next day. Today there are forty-five machines flying over the Rocky Mountains in all kinds of weather over inaccessible country; they have challenged the elements. This is most inspiring, especially when we think back and remember the little machine of about three years ago and compare it with the equipment we have today. Look back to the old Glidden tour days. Perhaps some of you kept your cars together long enough to make half of the Glidden tour. You did not expect to make all of it. Our aviators are doing better with their flying machines today than we did in the early Glidden tours.

We have crossed the Atlantic Ocean by seaplane, a thing we dreamed about for years. Even a year before it was done, when Admiral Taylor said he was going to do it, close as I was to the subject I thought the Admiral was attempting the impossible. But the thing was done. If you could have heard Commander Read, at the dinner in New York, describe so graphically his sensations when they came in sight of land on the other side, it would have thrilled you. He said he looked to his right and to his left and saw the four Liberty engines purring away each spitting out flame from all twelve cylinders, and realized that for 15 consecutive hr. or more they had not missed a single shot. He said he then appreciated what had put him across. The accomplishment was due to the efforts of members of this Society who designed and built the Liberty engine. You have difficulty in your own Speedway races. We can start an airplane race today and finish with about as few mishaps as are experienced in an automobile race. Few racing car engines could perform as the Liberty engines performed in that flight across the Atlantic. The Liberty engine was developed during stress of war and continued effort in the same line is imperative.

The airplane has great possibilities, but I do not believe that the aeronautic industry will become as large as the automobile industry. The little college at Granville, Ohio, is 100 miles from my front yard, and I go over there every other week. I get up at 8 o'clock in the morning, fly over there and attend a board meeting. I can fly back to my office and be there by 11 o'clock, and nobody knows anything about my having been away. Day before yesterday, an airplane started from the Dayton field and 4 hr. later landed at Mineola. Mr. Kettering left the same field and in 7 hr. was at Wichita, Kan., without a stop. You cannot take these things out of our lives. The problem of today is to surround the airplane with safety. We must provide safe landing fields and lay out routes. The first route really laid out in this country was between Dayton and Indianapolis, through the generosity of Carl Fisher. There is a landing field at each end of that route. I would rather take my chances in an airplane between Dayton and Indianapolis than take the

bumps and the chances by automobile. We do not know what is going to develop. Experiments have shown that a speed of over 300 m.p.h. can be attained in the higher altitudes, due to the velocity of the air currents. Some flyers have climbed as high as 34,000 ft.

Then, in the airship we have another line of development. When we think of the R-34 coming across the ocean, carrying passengers, it seems to us that there is a very practical thing for development. I do not know just what is coming out of it; nobody knows. A result that has been demonstrated is that aviation is not as dangerous as it is generally considered.

The maintenance of landing fields is a matter for every municipality. We need lighthouses in the form of wireless stations. We should eliminate stunt flying and get down to a commonsense basis. If we do these things the airplane business can be made safe and will become an essential part of our lives.

We had an aerial torpedo; an airplane that did not require any pilot, fixed up for the Huns. It would carry 200 lb. of T. N. T. When it reached the end of its journey it would shed its wings and drop as a bomb; you can imagine the result. We could sit here in Indianapolis and hit Dayton whenever we wanted to. We could not pick out the individual house we wanted to hit but we could hit Dayton. The torpedo could be shot at night as well as during the day. The machine was almost in production when the armistice was signed.

Importance of Research Engineering

We are living in a wonderful age. We are having great races between the engineer, the scientist and the coal pile. I want to bring home to you the necessity of getting your engineering work well in hand, and not going to sleep on the job of maintaining research in your factory business. I was recently amazed at something I learned in connection with Corliss engine work. We have considered the Corliss engine finished for so long a time that there is nothing more to do to it. We could cast and sell them at so much a pound, and the fellow nearest the place to which he shipped it made a profit of the difference in the freight rate. We had quit developing that sort of thing. The other day I saw a steam engine equipped with poppet valves. Its intake pipe was almost red-hot, and the engine had, it seems, astonishing efficiency. A poppet-valve locomotive is being built for the Pennsylvania Railroad. There is going to be an awakening in Corliss engine work. We found during the war that one of the German steamships, that had been doing such fine work, had poppet-valve steam engines, and that the Germans had been using that type of engine for a long time.

An individual who has quit making inquiries and stopped studying is through; has ceased to grow. Of all the people in the world the engineer ought to be alert in the matter of new developments. The internal-combustion engine is in its infancy. The fuel problem must be solved. The engineer who does not keep up-to-date is going to be out of the race. The same thing is true of a company. The moment a company ceases to advance in the thing that made it prosperous in the first place, it starts to go to the wall. In this or any other city you can find buildings, magnificent in their day, gone to ruin. In each case, some time, somewhere, some man has sat down and done some real studying, some engineering work and developed an industry; the business flourished, and because of the flourishing condition the research work was stopped, from strictly commercial considerations. Then suddenly it was found that some other engineer elsewhere had been busy, and the former business was wiped out of existence. That is the cycle of the individual and of business the world over. The thing to do is to maintain research work. No manufacturing enterprise, however small, can afford to be without a research laboratory of some kind. If I were making rocking chairs I would have one, though not necessarily an elaborate laboratory. I would have a rocking chair engineer on the job. He would not have to be a technical graduate.

Research engineering will be our salvation, but it must be conducted in a commonsense way. It cannot be done with a lot of elaborate apparatus and expensive laboratories. Good fellows with commonsense are needed to do the work from the ground up. If I can stir anybody here to take more interest in his research work, I will feel that I have done some good tonight.

I am very much in earnest about the engineering and research matters; I see the importance of them clearly. I covet for the Society the honor of taking the leading place in this advance work. It is a relatively new organization and it has a great opportunity. It ought to bristle with the latest developments along internal-combustion lines. Our civilization and progress will be measured more by the advance of internal-combustion engineering than by any other one thing.

AMERICAN MERCHANT MARINE

The United States Government should formulate a definite merchant marine policy and publish it broadcast. This policy must include the establishment of a fully competent organization for American registry. The demand for this rests upon the fact that at present Lloyd's registry is the only one recognized throughout the world, and American-built ships, as well as those purchased and operated under the American flag, must get their classification through Lloyd's. There can be no freedom of the seas or self-sustaining American merchant marine without the initial guaranty of American registry.

The next step must include the creation of an adequate American insurance organization. This could not be attempted without American registry. As the total investment in American shipping, in a period of less than 18 months, reached the huge total of nearly $4,000,000,000, the matter of establishing American insurance cannot be left to the gradual and normal growth of the few American companies that now exist. Just as the billions for building the ships were acquired through Governmental intervention, so the creation of an adequate American insurance organization must have Federal guarantee.

In developing a merchant marine policy the domestic shipbuilding and repair companies should be supported. They constitute the backbone of the industry, for without shipyards a nation cannot be independent, either in times of peace or the emergencies of war. It was the few American shipyards that had struggled along on Navy contracts and coastwise shipping patronage that formed the basis for our sudden and enormous shipbuilding expansion. When the shipping merchants and agents find that there are available American registry, American insurance, American ships and facilities for having them built and repaired in American shipyards, they can engage in foreign trade with some hope of success and compete on the free seas against the entire world. —*Transportation World.*

RATING TRACTORS ON PISTON DISPLACEMENT

EVER since the first Winnipeg tractor contests were held attempts have been made to have a formula based on cubic inches of piston displacement per minute recognized as a standard by which tractors are to be rated. The fact that attempts in this direction still persist indicates that the plan has some merit or else that its chief sponsors are unusually persistent.

There is need for a standardized method of rating which will be recognized and used by the industry. This fact is generally appreciated. The trouble seems to be that the industry has not been willing to accept a formula based on piston displacement. The chief objection has been that the powers indicated by this means do not always check with the results secured in tests. Of course "the proof of the pudding is in the eating." The block or the drawbar test must always be the final answer, but it would be desirable to have an empirical formula for rating purposes, providing the same will mean anything. Under these conditions it is desirable to analyze the performance of representative tractors in public tests on the basis of piston displacement to see what results have been attained.

The results reported from the tests conducted at the Central States Tractor Demonstration at Evansville, Ind., in October 1919, and the Ohio State University tractor tests, January 1920, furnish excellent material for this purpose. The machines entered were representative tractors. The conditions were favorable for a fair trial. The judges were competent and impartial. The tractors were operated by representatives of the various companies, which means that results approaching the maximum should have been obtained in most cases. The tables presented herewith give the summary of the piston displacements in cubic inches per minute per horsepower for the maximum tests.

Table 1 gives the summaries divided on the basis of kerosene and gasoline engines with further divisions on the basis of number of cylinders and whether the belt pulley was attached directly to the crankshaft of the engine or driven through gears. Table 2 shows the results which were obtained by the same makes of engine in the two tests.

TABLE I.—CUBIC INCHES OF PISTON DISPLACEMENT PER HORSEPOWER PER MINUTE.

Number of Cylinders	Fuel	Belt Pulley Drive	Evansville Maximum	Evansville Minimum	Evansville Average	Ohio Maximum	Ohio Minimum	Ohio Average
4	Kerosene	Direct	12,300	10,000	11,300	15,600	11,000	12,900
4	Kerosene	Gear	15,300	10,600	12,700	16,300	10,900	13,900
4	Gasoline	Gear	——	——	——	12,900	10,100	11,500
2	Kerosene	Direct	——	——	——	15,000	9,200	11,700

These data show some interesting facts. The lowest piston displacement is reported for a two-cylinder engine burning kerosene. This machine has provision for water injection with the fuel, which permits a high initial compression to be used. The lowest average for kerosene engines was also reported for those having two cylinders. Whether this is due to inherent advantages possessed by this type of engine or can be attributed to the fact that the companies producing these engines represent the pioneers in kerosene burning and therefore understand its use better, is impossible to say on the basis of the data presented, although the later would be the more logical supposition.

As might be expected, the engines burning gasoline gave the lowest average piston displacements, although the minimum reported was not as low as that for kerosene by 900 cu. in. It is reasonable to suppose, other factors being equal, that those machines which have the belt pulleys driven through gear transmissions will require a larger piston displacement to deliver 1 hp. on the belt than those which have the belt pulleys attached to the crankshaft. The average results reported for four-cylinder engines burning kerosene indicate that this is the case, as those which had belt pulleys driven through gear transmissions required 1000 cu. in. greater displacement on the average than those driven direct.

There is a great variation in the results reported for the engines of each class. In one case, four-cylinder kerosene burning, gear driven, this variation amounts to 49½ per cent. The figures in Table 2 show that there is in some cases a wide variation in the results obtained from the same engines in different tests. This condition is difficult to explain. It can be assumed that the identical engines were not used in both instances and that the operators were not the same. These facts may account for come of the differences.

TABLE 2.—CUBIC INCHES OF PISTON DISPLACEMENT PER MINUTE PER HORSEPOWER.

Evansville	Ohio
11,500	11,000
15,300	12,600
14,600	14,700
12,400	10,900
10,600	13,000

If these figures are typical of the results which can be obtained with tractor engines, and they should be, it is evident that no formula based solely on piston displacement will indicate the horsepower which an engine can be expected to develop. There are so many factors affecting delivered horsepower and standards of design vary so much that it is impossible to expect a simple formula to give accurate results in the present stage of development.

In studying these figures one is led to wonder to what extent volumetric efficiency measures the value of an engine for tractor purposes. It is certainly desirable if it can be attained without sacrificing other factors, such as flexibility, lack of detonation, lack of carbon deposits and proper cooling of the working parts. No matter what the final answer may be these figures furnish abundant evidence that there is still opportunity for engineers to study the factors involved in producing an engine which will handle the heavier fuels with maximum efficiency.

Under these conditions it would appear to be desirable to set up a piston displacement formula which engineers could use as a standard, to measure the results obtained in design work, but if this is done it should not be recommended as a universal method for the purpose of comparing one engine with another. The figures presented are from maximum tests of short duration.

It would seem reasonable that any formula proposed should be based on maximum performance for a period of not more than 4 hr. This of course will not indicate the rating that should be given. In fact, with the great variation which exists a formula set up as a means by which the engineer can test the result of design work would not necessarily have any relation to the rating given. The designer may have obtained better or worse results than the standard calls for.

An entirely different method should be used for rating purposes. Let a standard be set up by which the engineer can judge the results which he obtains. Then determine the maximum power which the engine will deliver on the belt for 4 hr. and take a certain percentage of this, perhaps 75, and designate this result as the belt-horsepower of the tractor.—E. A. White in *Farm Implement News.*

FOOD PRICES

WHILE food prices in the United States and Canada have risen 100 per cent since 1914, the increase was only approximately 60 per cent in Australia and New Zealand, but 200 per cent in Italy, 180 per cent in Norway, 150 per cent in Denmark, 140 per cent in Switzerland, and 130 per cent in Great Britain. For France the estimated increase is more than 200 per cent, for Belgium 350 per cent and for Sweden almost 200 per cent.—*New York Merchants' Association Bulletin.*

Load-Carrying Capacity of the Single-Row Groove-Type Ball Bearing

By ARVID PALMGREN[1]

Illustrated with DRAWINGS AND CHARTS

VERY few careful investigations of the carrying capacity of ball bearings have been made in the past especially in cases of combined radial and thrust loads. This is probably due to the great difficulties encountered in the theoretical calculations as well as in the experimental investigations of the problem. A description of the method used by the company with which I am connected illustrated by an application of it to a modern groove-type single-row ball bearing of the type shown in Fig. 1 may be of interest.

The distribution of the load between the balls of the bearing cannot be obtained from purely statical considerations. The elasticity of the material must be taken into account and it is essential to know the deformations and the forces producing them.

The coordinates used for measuring the relative displacement of the bearing rings under load have for their origin the initial center of the bearing. The x-axis is the axis of the bearing, the y-axis is in the direction of the radial load. Assuming the outer race stationary, the

FIG. 1

effect of the combined load Q is to displace the center of the inner race axially a distance denoted by x, and radially by y. In addition there is a tendency to rotate the inner race about the z-axis. This is due to the fact that Q does not pass through the origin and therefore produces a small torque about the z-axis (See Fig. 2).

However, as there is no measurable turning when the shaft is supported by two or more bearings, the deflection due to the torque is negligible for the type of bearing discussed here. It is therefore assumed that the effect of the load is to displace the inner ring parallel to itself. The compression δ of every ball in the bearing can then be taken as a function of x and y and the position of the ball which is determined by an angle v. This function is determined in what follows and from it is derived, by the Hertz Law, the individual ball pressures.

The summation of the individual ball pressures permits obtaining the total load in magnitude and direction Q is the magnitude of this load, Q_x and Q_y its thrust and radial components, φ the angle of the load Q with the y-axis.

The calculations are carried out for a sufficient number of values of x and y. Curves are then drawn expressing the maximum ball pressure P as a function of the load Q. From this auxiliary graph the desired diagram of the maximum ball pressure at varying thrust angle φ and at constant load is obtained.

[1]Engineer in charge of the experimental department, S K F Co., Gothenburg, Sweden.

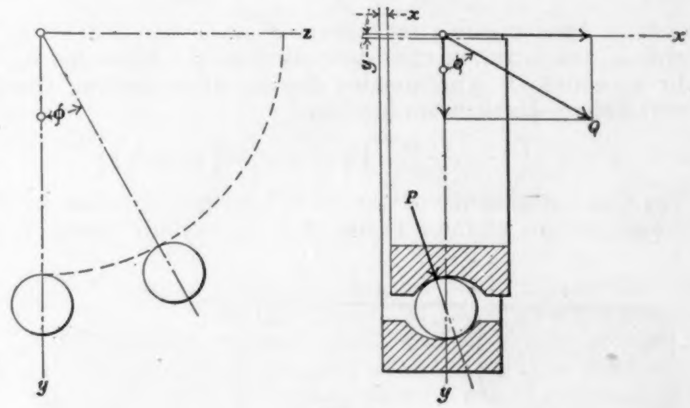


FIG. 2

The compression δ being small in comparison with the other dimensions of the bearing, the square and higher powers of δ can be dropped. Further approximations are obtained by considering the displacement y small with respect to x.

The symbols employed in the discussion which follows are given below and their relationship can be seen in Fig. 3 on page 336.

- P is the maximum ball pressure
- C is a constant depending upon the curvatures of the surfaces in contact as well as the elastic characteristics of the materials used
- δ is the compression of every ball in the bearing
- d is the decrease in the distance between the points of contact on the rings due to the compression of the balls under load
- d_0 is the total initial clearance between the balls and the two races
- y is the displacement of the inner ring along the y-axis under load.
- v is the angle of location of the ball
- α is the angle between the initial center line of the grooves and its new position after the load has been applied
- x is the displacement of the inner rings along the x-axis under load
- a_1 is the vertical projection of the line of groove centers
- a_0 is the initial distance between the centers
- r_1 is the radius of the inner race groove in the plane through the axis of the shaft
- r_2 is the radius of the outer race groove in the same plane
- r_0 is the radius of the ball

According to the Hertz formula

$$P = C\delta^{\frac{3}{2}}$$

We know that

$$\delta = d - d_0 + \frac{y \cos v}{\cos \alpha}$$

For α we have

$$\tan \alpha = \frac{x}{a_1}$$

Then

$$a_1 = a_0 + y \cos v$$

and we evidently have

$$r_1 + r_2 - a_0 = 2r_0 + d_0$$

Hence

$$a_0 = r_1 + r_2 - 2r_0 - d_0$$

For d we have a value of

$$d = \frac{a_1}{\cos \alpha} - a_0 = a_0\left(\frac{1}{\cos \alpha} - 1\right) + y\frac{\cos v}{\cos \alpha}$$

Consequently

$$\delta = a_0\left(\frac{1}{\cos \alpha} - 1\right) - d_0 + 2y\frac{\cos v}{\cos \alpha}$$

It is then possible to express P as a function of y and α, the latter in turn depending on x. Replacing a_1 by a_0 which it approximates closely, after making the necessary reductions we find that

$$P = C\left[\left(1 + \frac{2y \cos v}{a_0}\right)\sqrt{a_0^2 + x^2} - \left(a_0 + d_0\right)\right]^{3/2}$$

The two components of the total load are obtained by the summation of these values of P for various values of

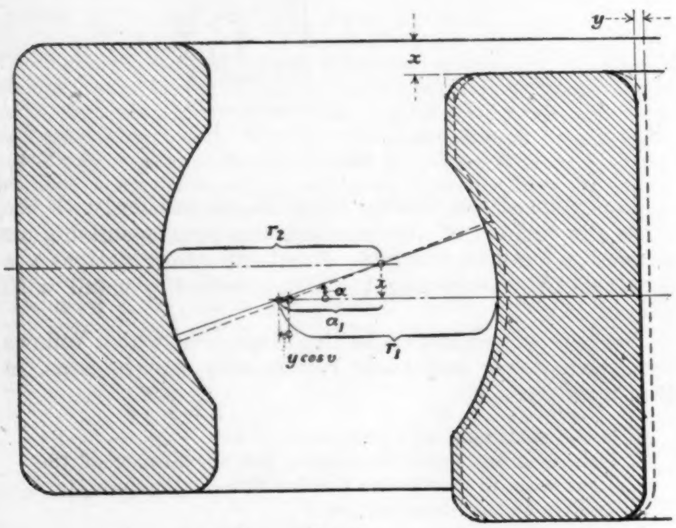


Fig. 3

the angle v. We then have as the values of the thrust and radial components of the total load

$$Q_x = (\Sigma P) \sin \alpha$$
$$Q_y = (\Sigma P \cos v) \cos \alpha$$

The calculations have been carried out for a groove-type bearing of the following dimensions:

Shaft diameter, mm.	45.00
Outside diameter, mm.	100.00
Width, mm.	25.00
Ball diameter, mm.	16.50
Number of balls	12.00
Radius of inner race, mm.	28.75
Radius of groove of inner race, mm.	8.60
Radius of outer race, mm.	45.25
Radius of groove of outer race, mm.	8.90

The curves which represent the relation between the maximum ball pressure and the bearing load for different values of x and y are found in Fig. 4 and the curves which represent the relation between the maximum ball pressure and the bearing load for different directions of this load are found in Fig. 5. The former should be considered as an auxiliary diagram for plotting the latter which shows graphically the value of the maximum ball pressure for all different load combinations of the bearing, this pressure being a measure of the load capacity of the bearing.

Theoretical deductions are not, however, always sufficient when problems as complicated as the present one have to be solved. There is always a danger that approximations have been made which have a greater influence on the result than was expected. Such calculations should therefore always as far as possible be verified by experimental investigation.

Experimental Methods Used

In the present case it is rather difficult to carry out such experiments. I have, however, succeeded in developing two suitable methods according to which investigations have been made. One of the methods which has been mainly used is based upon the assumption that the free surface around the pressure surface is chemically changed while the pressure surface itself is protected and maintains its original condition. After the ball has been removed the pressure surface can then be studied as to its size and shape. As an etching medium a solution made by dissolving 20 grams of mercuric chloride $HgCl_2$ in 400 cu. cm. of boiling water to which 8 grams of copper chloride $CuCl_2$ was added was poured into a solution of 10 grams of bismuth chloride $BiCl_3$ dissolved in 4 cu. cm. of hydrochloric acid HCl and stirred rapidly, after which 40 cu. cm. of alcohol was added and the liquid boiled.

The etching fluid was introduced with a brush around the ball in the wedge-shaped space nearest to the pressure

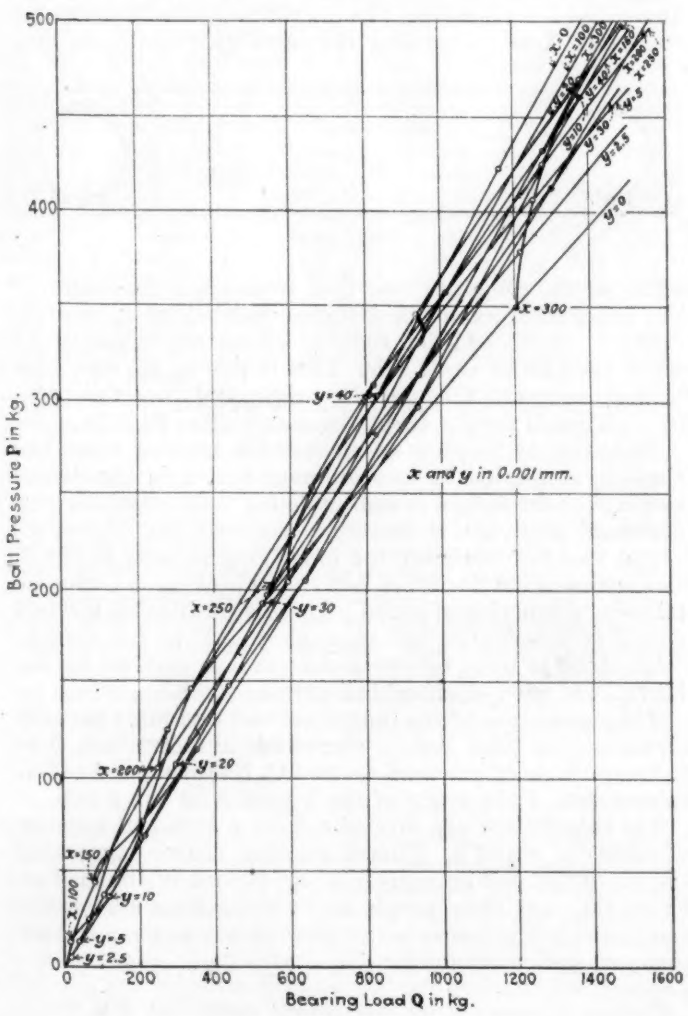


Fig. 4

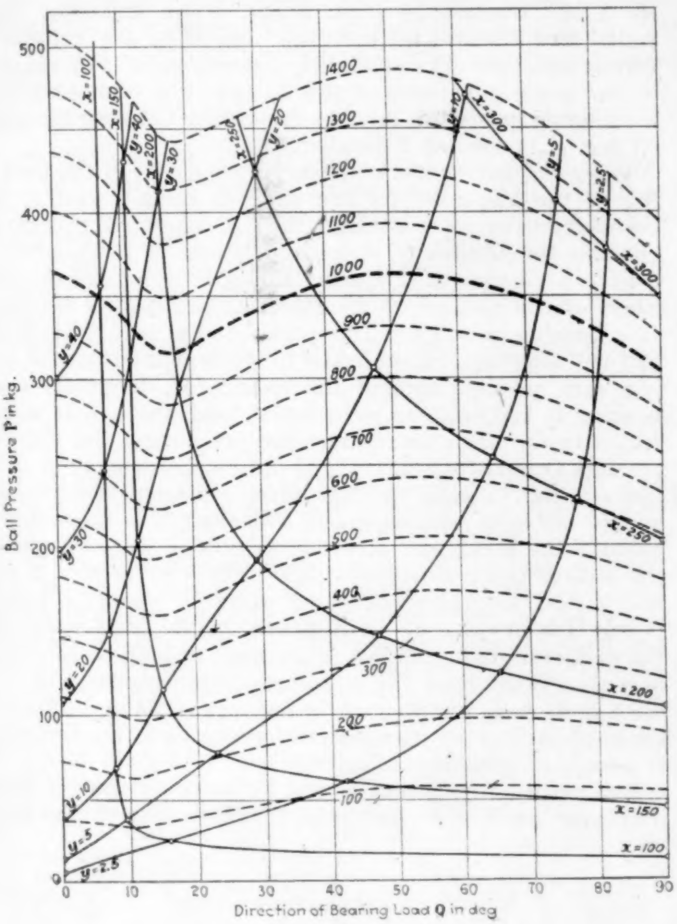


FIG. 5

surface. A thread was laid around the ball and pulled back and forth so that the liquid was put in motion and penetrated to the outline of the pressure surface. As the distance between the two bodies is infinitely small the surface must be thoroughly cleaned and washed with gasoline. The ball must remain under pressure for a few minutes after which the liquid is wiped off and a few drops of alcohol are introduced to prevent further etching after the pressure has been removed.

As a check a new process has been used which is similar to the sooting method of Hertz. The etching fluid is applied to the surface which is to be investigated and wiped off immediately and carefully with a piece of soft linen or some other fabric. A very thin layer of mercury and bismuth is then formed on the iron and this layer shows the pressure surface when the two bodies are pressed against each other. To measure the pressure surface thus obtained the light must be very good and directed in a proper way against the surface. The use of the two methods has shown that each one gives very reliable values as the readings taken by the two methods check perfectly.

The readings of the linear dimensions of the pressure surface have been made with the aid of a microscope. The average accuracy was within ½ per cent. The measurements on the bearings were made by inserting the bearing in a fixture which enabled the load to be applied in any desired direction through the center of the bearing. The bearing was loaded to 1000 kg. and the pressure on the ball carrying the maximum load was investigated by the etching process. This method of determining the pressure requires that the relation between the pressure and the length of the major or the minor axis of the pressure ellipse be known exactly. This relation was therefore first established by the insertion of a single ball to which different pressures were applied and the corresponding pressure surfaces measured.

The results of these preliminary measurements are shown in Table 1 and graphically in Fig. 6.

TABLE 1—RELATION BETWEEN PRESSURE SURFACE AND BALL PRESSURES

Load between Ball and Inner Race, kg.	Length of Major Axis of Pressure Ellipse, mm.					Average
136	3.35	3.35	3.35	3.52	3.46	3.41
236	3.95	4.05	4.03	4.07	4.07	4.03
335	4.35	4.45	4.40	4.54	4.54	4.46
435	4.80	4.82	4.70	5.09	4.85	4.85
500	5.05	5.10	....	....	....	5.08
534	5.23	5.21	5.20	5.26	....	5.23
634	5.40	5.45	5.41	5.65	....	4.48
1,000	6.20	6.15	6.25	6.20	6.20	6.20
2,000	7.68	....	....	....	....	7.68

This relation could also have been figured according to the Hertz formula but this would necessitate the use of his approximations and it would furthermore be necessary to make certain assumptions as to the modulus of elasticity E. The two methods agree very well if E is assumed to be 2,100,000 kg. per sq. cm. At very high pressures the difference may however become considerable as Fig. 6 shows.

The measurements of the complete bearing are shown

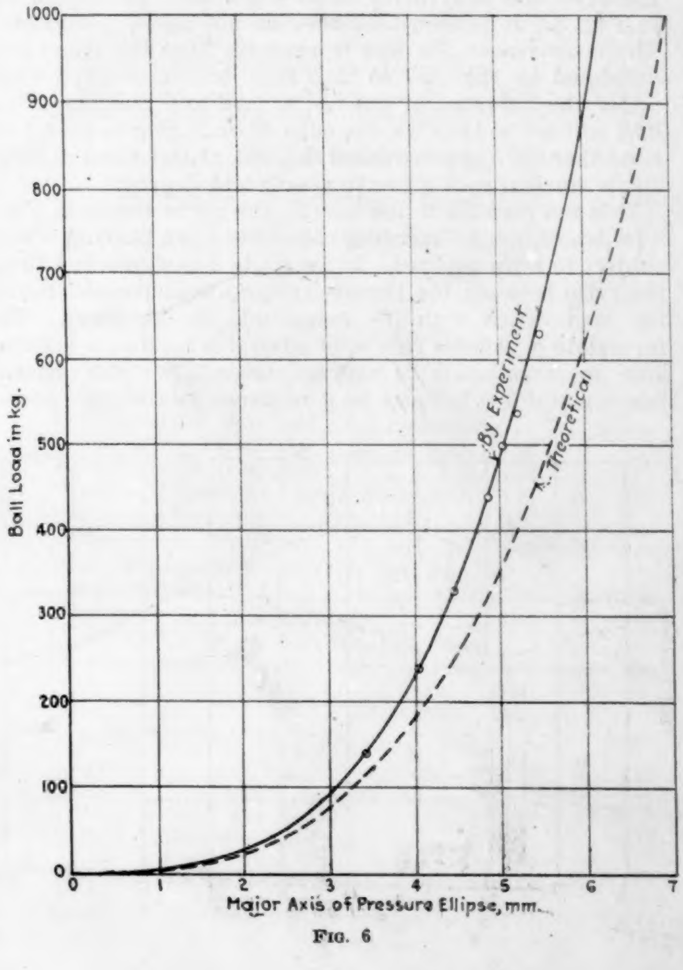


FIG. 6

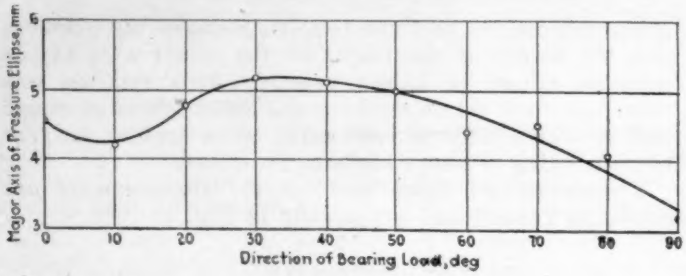


FIG. 7

TABLE 2—BALL PRESSURE FOR DIFFERENT DIRECTIONS OF THE BEARING LOAD $Q = 1000$ KG.

Angle, deg.	Length of Major Axis of Pressure Ellipse, mm.						Average	Ball Pressure, kg.
0	4.50	4.50	4.55	4.65	5.05	5.05	....	...
	5.15	4.80	4.95	....	....	....	4.80	415
10	4.60	....	....	....	....	....	4.60	375
20	4.80	5.00	....	....	....	....	4.90	443
30	5.00	5.30	5.25	4.82	....	....	5.09	503
40	5.00	5.15	....	....	....	....	5.08	500
50	4.90	5.05	....	....	....	....	4.98	471
60	4.45	4.70	5.05	....	....	....	4.73	400
70	4.75	....	....	....	....	....	4.75	410
80	4.55	....	....	....	....	....	4.55	350
90	4.00	4.67	3.40	3.40	4.45	4.55	4.08	247

in Table 2 and Fig. 7 on page 338. By the use of the curve in Fig. 6, it is possible to find the desired value of the maximum ball pressure and this is given in the last column in Table 2.

The comparison between the theoretically figured ball pressure and that determined experimentally is shown in Fig. 8. It is seen that they do not agree completely. The main reason for this is probably that the rings are deformed by the load so that they become slightly oval under the influence of the radial load and that the axial load will act so that the one edge of each ring is bent. It must therefore be considered that calculations and experiments confirm each other to a sufficient degree.

It is not possible to use exactly the curve shown in Fig. 8 to determine the carrying capacity of the bearing when subject to a thrust load. If we study Fig. 5, we find that the ratio between the thrust-carrying capacity and bearing load varies with the magnitude of the latter. To formulate a general rule it is advisable to choose such a load as corresponds to average cases. For the chosen bearing size 500 kg. may be considered as a normal serv-

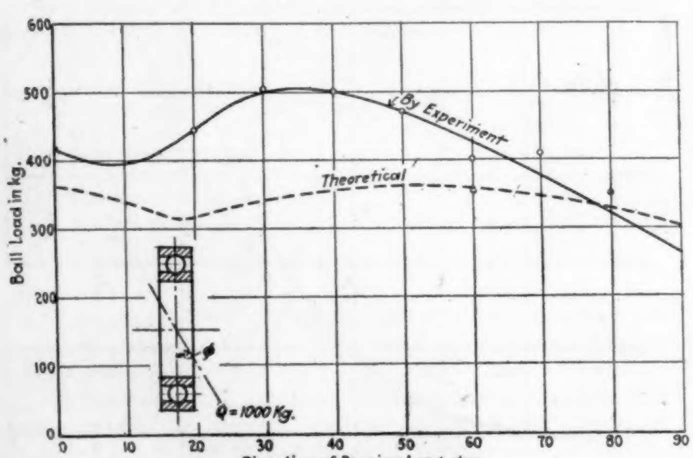


FIG. 8

ice load. Comparing Figs. 5 and 8, we find that the radial and thrust-load carrying capacities are approximately equal at this and slightly lighter loads. For values of the angle φ between 0 and 20 deg. the load-carrying capacity is somewhat larger; for values between 30 and 60 deg. it is somewhat smaller.

When estimating the load-carrying capacity of the bearing or the length of its life under a certain load it is necessary to consider not only the maximum ball pressure but also the number of stress repetitions in the bearing. This is necessary as a bearing slowly deteriorates on account of the fatigue of the material and flaking occurs. If a bearing is subjected to purely radial load a certain ball will only once be subjected to the maximum load during each passage around the shaft. If, however, the bearing is subjected to pure thrust load, the ball is subjected to the same maximum pressure during the entire passage around the shaft. This different character of the loads within a ball bearing under different conditions causes different phenomena of fatigue. The more frequently the maximum stresses occur at a certain point the sooner the bearing will fail. For this reason it is not logical to figure the same carrying capacity with purely thrust load as with purely radial load even if the maximum ball pressure is the same in both cases. The only way to establish this difference is by extensive tests. Such tests have shown certain influence of the different kinds of fatigue but the material gathered is too limited to permit of reliable conclusions.

For practical purposes it can be assumed that if the maximum loads are intermittent and consist of shocks,

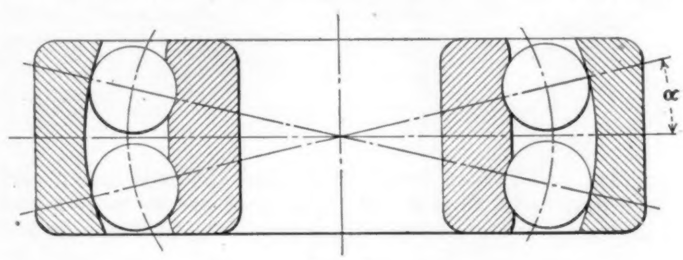


FIG. 9

the bearings will have a more favorable thrust-load carrying capacity such as shown by Fig. 7 and the maximum stresses in the bearing are not so great. It is in that case fair to assume that the carrying capacity of the bearing is the same for all directions of the load. If, however, the loads are even, we find that the thrust load-carrying capacity of the bearing is comparatively lower and that the balls are subject to a greater number of fatigue stresses. For this reason and to be on the safe side it is advisable not to permit a thrust load to exceed one-third of the permissible radial loads. This assumption gives us the following simple formula for the safe load of a groove-type bearing which will apply to all load combinations:

Total load = Radial load + three times thrust load

DOUBLE-ROW SPHERICAL BEARING

In addition to the groove-type bearing the double-row spherical bearing is also of interest. The methods of investigation are, however, the same in both cases and therefore only the result will be mentioned. The narrow spherical bearing has a radial load-carrying capacity which is slightly greater than the capacity of the groove-type bearing. If it is required to carry heavy thrust loads, the wide type should be used, the thrust and radial

load carrying capacity of which is approximately the same as the capacity of the groove-type bearings.

For the spherical bearings the following formula applies:

$$\text{Total load} = \text{Radial load} + \frac{1}{\tan \alpha} \times \text{thrust load}$$

In this formula α is the pressure angle shown in Fig. 9. In case of narrow spherical bearings, the reciprocal of tan α is on an average equal to 6 and in case of the wide-type spherical bearings it is approximately equal to 4. In deriving the formula consideration is given to the different fatigue effects for different directions of the bearing load.

As a result of our tests of ball bearings of different types and under various load conditions it has been shown that the standard double-row spherical bearing should be preferred where the load is radial or nearly so, but where considerable thrust loads occur the wide-type spherical bearing or a groove-type bearing is preferable. Different groove-type bearings have, however, very different characteristics. A groove-type bearing with a filling slot is, in spite of the greater number of balls it contains, less capable of carrying thrust loads than a groove type without such a slot. For such loads it is however, as above noted, preferable to use a spherical bearing. It is therefore always possible to obtain the best ball bearing application by the use of spherical bearings or groove-type bearings without a filling slot.

RESULT OF LETTER BALLOT ON STANDARDS

At the Semi-Annual Meeting of the Society held June 21, 49 recommendations of 14 Divisions of the Standards Committee were approved for final presentation to the voting members of the Society. These were adopted in their entirety by the letter ballot which closed on Aug. 20. The reports on which this action was taken were printed in The Journal in the August issue, on pages 195 to 210 inclusive. The reports have also been reprinted in pamphlet form, copies of which may be obtained from the Society.

The complete vote on the recommendations is given below. The first column gives the number of affirmative votes cast; the second, the negative votes, and the third, the number of members who did not vote either way.

Aeronautic Division			
Systems of Measurement	108	1	175
Supports for Engines	95	1	188
Shafts for Propeller Hubs	96	0	188
Engine Testing Forms	113	1	170
Engine Weight Specifications	101	1	182
Automobile Lighting Division			
Head-Lamp Mounting	159	1	124
Electric Incandescent Lamps	162	0	122
Head-Lamp Nomenclature	163	0	121
Head-Lamp Brackets	151	4	129
Head-Lamp Lighting Nomenclature	161	0	123
Head-Lamp Illumination	157	0	127
Electric Transportation Division			
Clearance Radii	100	0	184
Brakes	102	3	179
Storage Battery Trays	99	2	182
Electrical Equipment Division			
Electrical Instrument Mounting Dimensions	148	1	135
Engine Division			
Connecting-Rod Bolts	180	0	104
Iron and Steel Division			
Valve Metals	180	0	104
Tungsten Steels	179	0	105
Nickel Steels	186	1	97
Miscellaneous Division			
Brake Linings	169	0	115
Oil and Grease-Cup Threads	177	1	106
Fuel Vacuum-Tank Mounting	160	0	124
Motorcycle Division			
Motorcycle Fuel and Lubrication Pipe Fittings	84	1	199
Oil and Grease Cups	81	1	202
Motorcycle Spokes and Nipples	68	1	215
Cylinder Displacement	84	0	200
Carrying Capacity	83	0	201
Motorcycle Tires	83	0	201
Kick Starter	78	0	206
Roller Chain Division			
Roller Transmission Chains—Heavy Series	113	0	171
Roller Transmission Chains—Medium Series	112	1	171
Roller Transmission Chains—Light Series	112	1	171
Roller Transmission Chain Sprockets	111	0	173
Springs Division			
Eye Bushings and Bolt Tolerances	155	0	129
Shaft Fittings Division			
Taper Fittings with Plain or Slotted Nuts	165	1	118
Tire and Rim Division			
Automobile Rim Valve Holes	129	4	151
Felloe-Band Tolerances	133	0	151
Deflection and Set Test of Automobile Pneumatic Tire Rims	123	4	157
Motorcycle Rim Sections	102	0	182
Carrying Capacity of Solid Tires	123	0	161
Pneumatic Tires for Passenger Cars and Commercial Vehicles	140	0	144
Rim Sections and Contours for Pneumatic Tires	127	4	153
Pneumatic Tire Felloe Bands	132	0	152
Carrying Capacities and Inflation Pressures for Motorcycle Tires	105	0	179
Tractor Division			
Tractor Drawbar and Belt-Power Ratings	126	0	158
Steels for Tractors	127	0	157
Tractor Screws and Bolts	133	0	151
Height of Tractor Drawbar	119	0	165
Transmission Division			
Control-Lever Ball-Handle Inserts	111	2	171

JULES VERNE

JULES VERNE was the world's greatest scientific prophet. Every reader knows Twenty Thousand Leagues Under the Sea and its sequel, the Mysterious Island, with their romance of Captain Nemo and his submarine. There were no submarines when that tale began in 1870, and only with the remarkable supersubmarines constructed in the last year of the great war have we really paralleled Captain Nemo's boat.

In the Steam Horse, published in 1881, Verne planned an automobile, depicting ordinary steam as the motive power. Later, in his Master of the World, he uses gas and electricity as the sources of power of an automobile, giving it a speed of 100 m.p.h.

In Robur the Conqueror, published in 1886, Verne not only pictured the conquest of the air, but foresaw the struggle between the lighter-than-air and the heavier-than-air types, awarding the triumph to the latter. The air machines in Robur the Conqueror pale before the marvelous machine depicted in the later book, the Master of the World. Here the earlier hero, Robur, reappears with an invention which travels equally in the air, on the land, on the seas and under the seas. Electricity is prominent in all of these books. Verne saw well the part it was to play. Electric machines, some not wholly realized yet, form the main source of light and power in his visioned world. The Castle of the Carpathians centers its story on the invention of a phonograph. The Floating Island depicts dozens of electrical and mechanical devices, reaching beyond the telephone and describing a telautograph, and a kinetograph by which electric pictures are drawn.

As to chemistry, Dr. Ox's Experiment foreshadowed the value of oxygen gas as a stimulant and reviving force. The Star of the South deals with the making of synthetic diamonds, the Underground City takes us into the miner's world of coal and its dangerous gases. Compressed air and compressed food are among the master's earliest conceptions of what has since been accomplished along these lines.

Most marvelous of all perhaps are the stories of great guns and high explosives. In the war when Germany suddenly bombarded Paris from a 70-mile distance, many scientists declared the thing absurd, impossible. They should have known their Jules Verne better. His first concept of such a cannon, hurling a projectile at once above the atmosphere and so escaping friction through the main distance of its flight, was developed fantastically in his Trip to the Moon. We have not yet duplicated that giant gun which shot the voyagers forth beyond our planet's gravitation.

More nearly in line with the actual developments of the war were the explosives pictured in For the Flag, Purchase of the North Pole and Millions of the Begum. When after Verne's death I was called on to edit an edition of his works I felt it necessary to apologize for the Begum book with its hideous and awful picture of the German scientist, so ready in destruction, so exact with his mechanisms, so brutal in his soulless use of them; I could not then believe in such a German mind. You will understand the world war better if you reread the vision of it in the grim and terrible prophecies of this, Verne's ugliest book, written decades before the world war.

In the Desert of Ice Verne carried us to the North Pole and made us see its bleak and empty world very much as Peary has since made us see it. He built a story also on the South Pole, the Sphinx of Ice. Here he avowedly carried on a fantasy begun with our great American romancer, Poe; so Verne was pledged to Poe's beginnings and visualized for us a Southern world of heat and wild people and electrical mysteries wholly foreign to the bleak land Shackleton and others have since explored. The Sphinx of Ice stands alone as a Verne book which time has contradicted.

Of still further reachings into the unknown, on which man cannot yet render a verdict, were Verne's Journey to the Center of the Earth, which no man seems likely to achieve soon; and his Off On a Comet, which takes the reader to our sister planets. Yet it is notable that in both these books, as in the Trip to the Moon and its continuation, the Tour of the Moon, later knowledge has followed the lines suggested by Verne. Instead of playing with idle fantasies of unknown worlds, Verne studied all we knew of other planets and our own, and keenly judged what conditions visitors to the farther worlds would be most likely to encounter. How much, I wonder, of the scientific progress of today do we really owe to Verne? Our country can almost claim him as more American than French.—C. I. Horne in *Science and Invention*.

INTERNATIONAL DEBT AND ECONOMICS

THE wealth and productive capacity of the United States is from one-third to one-half that of the entire world. The capacity of this country for producing iron and steel and labor-saving machinery and all the equipment and all the industry is practically equal to that of all the rest of the world put together, even if they were in working condition. So it is with supplies of raw materials. We have the natural resources and the ability to produce them in quantities as no other nations have. We have what Europe needs and what she can get practically nowhere else. Furthermore, we have the financial resources to extend the relief. We went into the war a debtor country, and we came out a creditor country. We have bought back the great quantities of American securities that were held in Europe, and we bought them back very cheaply.

The people of Europe have the fundamental basis of credit. The soil of Europe, the industrial credit of Europe, the accumulated wealth of Europe in many forms is vitally more important than all the populations of Europe to furnish abundant assets. The population of Europe is an industrious, skilful population. They are a wealth-producing, thrifty people. It is true their indebtedness is large, but aside from what they owe us, they owe it practically all to themselves, and no people ever went bankrupt on payments they made to themselves. There is a great amount of confused thinking about the burden of the indebtedness which a people owe to themselves. The payments are going to be paid back into the same community and the mere payment of a debt does not extinguish the capital that is transferred.

The debts of Great Britain at the end of her wars with Napoleon were very much larger in proportion to the population and wealth of the country, than her debt is today, and Great Britain never did pay off the debts of the Napoleonic wars. They exist in the form of consols today; but through the scientific application of steam to machinery, by the development of machinery, she so increased her productive capacity that she was able to make loans in the form of equipment to other countries, to build railroads in the United States and in other countries, so that she built up a great and profitable foreign trade, and at the same time increased the production of foodstuffs all over the world to such an extent that she cheapened the cost of foodstuffs to her own people, having entered upon a career of prosperity such as she had never known before. Thomas Huxley, one of the great English writers upon science, made the statement some years ago that all the costs of the Franco-Prussian war, including the billion dollars of indemnity, had been more than offset in France at almost the same time by the scientific discoveries of one Frenchman, Louis Pasteur.—George E. Roberts.

CARBURETER TUNING FOR ECONOMY

THE three requirements of carbureter tuning for economy are (*a*) maintaining a minimum spraying velocity around the jet or jets, (*b*) avoiding over-rich spots anywhere in the throttle curve, but especially in the neighborhood of average running positions and (*c*) an adequate reduction of jet size as the running temperature rises where carbureters with uncontrolled jets are employed.

The mere fact of supplying air and gasoline in the proper proportions is not enough; they must be supplied in such a way as to form a suitably-disintegrated and therefore readily-combustible mixture, and to do this a certain minimum air speed is necessary. In the case of open carbureters such as the Zenith, Solex and Sthenos, in which replaceable choke tubes are fitted, the selection of a correct size is all that is necessary. The Claudel, having a fixed maximum air-way, has no adjustment other than changing the carbureter while the constant-vacuum types such as the S. U. Smith, and Stewart Precision, having a fixed velocity at all speeds, in cases where an alteration is desirable, require their valves to be weighted or lightened, according as an increase or a decrease is desired.

When the minimum velocity for effective spraying has been reached, it will be found that any further increase in choke diameter will require a disproportionate fuel enrichment, due to insufficient breaking up of the spray. The gasoline in this case passes into the cylinder in a coarse state of subdivision, and a certain proportion of it is ejected, unburnt, at the exhaust. If economy is aimed at, therefore, it is preferable always to use the smallest choke with which the desired speed can be obtained, and tune to it the smallest main jet that will give the necessary power. In the case of the Zenith, the choke encloses both the main and the compensator jets; therefore, their output must be regarded in the aggregate where the choke area is concerned. In the cases of the Claudel, Solex and Sthenos the main jets only have to be considered in determining the choke size.

Assuming the calibration of these members to be in metric measurements, the average maximums would be approximately in the following progressions: 17 choke and 80 jet, 18 and 85, 19 and 90, 20 and 95, etc., the choke sizes going up in even millimeters and the jets in increases of 5 mm. When a choke requires a jet appreciably in excess of the above relation, the choke setting immediately becomes an object of suspicion. In the case of constant-vacuum instruments mentioned, the correct air velocity is determined by noting the height to which the automatic valve rises. It should not come to the top of its lift before the maximum speed and a fully-open throttle have been attained; should it do so, insufficient velocity is indicated.

Regarding over-rich spots in the throttle curve, where the constant-vacuum class is concerned, it is mainly a case of carefully curing all induction air leakages and having a needle or metering pin of the correct taper, but with the open types the problem is rather more complex, a small jet spraying at the throttle edge dealing with the slow-running and starting positions, and its overlap with the main member being the point to be watched, especially in town work, where the average speeds are low. Here, again, the economic advantage of a small choke is evident, for the smaller this is the higher the velocity and the sooner the main jet comes into action and consequently the slow-running arrangements can be proportionately cut down without courting a "flat spot."

A fairly safe general rule to follow in the case of the four open carbureters mentioned is: When the average speeds are low, use a small choke with suitably reduced main jet; be sure that there is no induction leakage and cut down the slow-running jet to a point as nearly approaching a "flat spot" as possible. If the latter reduction cannot be made without causing bad starting and erratic slow running, a leakage is indicated, which must be discovered and cured before good results are possible. All carbureters of whatever make, if adjusted to run well when cold will be unnecessarily rich when hot and conversely if adjusted to the best economic advantage when hot will be sluggish and inflexible when cold; this is a physical quality of the fuel and quite apart from mechanical design. If, therefore, the jet is not controlled from the dashboard, either an extra air device must be fitted for economy, or a careful compromise effected just to carry over the cold period and no more. The great majority of cars run wastefully when warm because their drivers have not the patience to put up with sluggishness and inflexibility when cold. If low consumption is desired in the case of a carbureter not fitted with a variable jet or extra air there are only two alternatives, patience or waste.

In the use of benzol greater economy can be obtained if the carbureter and ignition settings are altered. The float should be weighted to bring the level to the same height as when using gasoline. Experiments should be made with smaller choke-tubes and smaller jets, if greater economy without loss of power is desired, together with a clean-running engine. As the detonating point of benzol vapor is lower than that of gasoline, the ignition can be advanced with advantage. A further improvement can often be obtained by fitting an extra air device. A gain in fuel of as much as 20 per cent can often be obtained by using benzol after the carbureter has been correctly adjusted for this fuel.—*The Motor.*

THE FUTURE OF TRANSPORTATION

AIRSHIP and airplane transportation will become the controlling factors in the nation's commerce. To ship by air will be a common slogan of being up to the minute and today the basic data upon which that slogan can be founded is proved by over a year of successful and profitable operation. The world's airways go on forever, there is no seaboard, there are no rails, the right-of-way is universal and free. Air mail routes have already been in operation in the United States for two years with records of high performance and also of great saving and economy to the Government. Department stores, express companies and others have followed closely in its wake so that while the United States is at present far behind the European countries in commercial aviation, the time is here when we will not only equal but rapidly outstrip them and take first place.

In France, England and Germany there is already daily commercial aeronautic activity on a large scale. In France lines radiate from Paris to Lille, Brussels, London, Deauville and Cherbourg. In England Government airdromes provide "garage" service for the nominal fee of $1, which includes overnight storage and assistance in starting and alighting. So popular has flying become that the installation of beacons to encourage night flying is being considered. Regular daily schedules are maintained on three lines for passengers and express from London to Paris and now even Holland is connected by air with London. Cape Town, Australia and Constantinople have been reached by air from England and the trail blazed for the many followers of the future. Italy also has been proposed an extensive service, some of which is now being tried out.—*Air Service News Letter.*

Tractor Wheels

By A. W. SCARRATT[1] MINNEAPOLIS SECTION PAPER

WE have devoted considerable thought to rolling resistance for the past three years, with a view to eventually recommending the best type of traction-producing equipment to be used on wheels. Three distinct types of wheel equipment are best able to meet conditions in the field; the pyramid lug, the spade lug and the angle-iron cleat. On road work it is necessary to use a different kind of cleat equipment which should be of less height and greater width so as not to destroy the road surface; it is also good for hauling. Tractor use on the road is very small compared to its use in the fields, and our efforts should be devoted to developing field equipment.

Pyramid lugs are especially effectual for sod plowing and where the penetration must be to a considerable depth to get good traction. Spade lugs are especially suitable for good plowing conditions, where the moisture content is about right and the fields have been cultivated for some time. The same thing applies to the angle-iron cleats, especially where the ground is of a light nature.

To give an idea of the influence of the slippage, I will cite an instance in Canada. We plowed near Winnipeg in the fall, and tried at first to get along with pyramid lugs. This land is the ordinary Red River gumbo. The ground had become so thoroughly dry that it was exceptionally loose on top; but about 3 or 4 in. under the surface it was firm and hard. We had to go over it six or eight times. We then replaced the pyramid lugs with 2½-in. angle-iron cleats. The slippage with the pyramid lugs had been about 16 per cent. With the 2½-in. angle-iron cleats the slippage was cut down considerably, to about 11 per cent. We then tried 3½-in. cleats and the slippage was cut down to 4 or 5 per cent.

No one kind of wheel equipment can be recommended as a universal type, from the experience we have had. We are providing the purchaser of a tractor with any of the three types of wheel equipment that he and his dealer think will best meet the conditions of the land. It seems to me that the user should provide himself with more than one kind of wheel equipment. If the land is of a rolling nature or only partly under cultivation and there is sod plowing to do, discing and harrowing will obtain the best results by changing wheel equipment for the different classes of work.

We tested some tractors in Texas about a year ago. This work was done in a field that had never been plowed before. It was in a "hog-wallow" and was full of shallow spots which filled up with water during rains. A track-laying tractor had first been put in the field, to plow it to a certain price per acre. We were informed that in four weeks it plowed 5 acres. In the end, it was so badly mired that they could not get it out. We arrived with the wheeled machines and equipped them with angle-iron cleats. We pulled the other machine out and then plowed 650 acres while water was standing on the ground. This is one case where the tracklaying type of tractor was a complete failure.

I have talked with men who are familiar with the paddle type wheels, and been told that, in tests run in Texas, these became completely inoperative after being in a sticky field a short time. All of the equipment built with that type of wheel to develop traction became useless; the ground clung to the mechanism until it was impossible to operate the tractor.

[1] M. S. A. E.—Automotive engineer, Minneapolis Steel & Machinery Co., Minneapolis.

THE DISCUSSION

A MEMBER:—Do 3½-in. cleats penetrate the ground unduly?

A. W. SCARRATT:—The edges bite into the surface, but that does not always mean 3½ in. below the surface.

A MEMBER:—What size of tractor was used?

MR. SCARRATT:—The so-called 12-20.

A. M. LEONI:—Is it possible to decide upon a certain size of wheel for all tractors?

MR. SCARRATT:—In designing a machine it is of course necessary to consider many things. It is important to build a three-plow tractor narrow enough to have both wheels on the land, to avoid side-draft. The size of the wheel will be influenced by the type of transmission. There must be a reasonable ground clearance. The class of work it is proposed to cater to will influence the design of the tractor, especially as to wheel size and arrangement. A very low tractor would compel the use of small wheels. It will be difficult to get a common understanding as to just what dimensions tractor wheels should have. In our efforts to lay out what we consider an ideal three or four-wheel-plow tractor for general farm work, it is possible to standardize on wheels.

OIL-ENGINED SHIPS

AS to the advantages of adopting the marine oil engine as a prime mover for merchant marine, G. A. Colley in *Transportation World* gives the following figures obtained from two large merchant ships of foreign make, a motorship and an oil-fired steam-driven ship of exactly similar dimensions and designed speed, both of which have been in operation for some time.

	Steamship	Motorship
Cargo Capacity, tons	7,970	8,925
Fuel Capacity, tons	1,300	1,300
Average Sea Speed, knots	12	12.5
Cruising radius, miles	10,296	31,200
Daily Fuel Consumption, tons	38	12.5
Lubricating Oil Consumption per day, gal.	7	12
Engine Room Crew, men	23	17
Reduction in Crew, men		6
First Cost per Deadweight Ton of Cargo	$175.65	$172.54

Although the total first cost of the motorship exceeds by about $140,000 the first cost of the steamship, the actual cost per ton carried is less for the motorship.

CANADIAN AUTOMOBILE SALES

IT is stated that sales of automobiles in Canada in 1919 totaled $100,000,000. Last year 94,000 cars were manufactured in Canada, and the output for 1920 is expected to show an increase of 35 per cent.

The Science of Standardization[1]

By ROBERT S. BURNETT [2]

THE general subject of standardization is broad and important, affording opportunities for careful study from many points of view. It is intended, however, to limit this paper to a brief outline of the organization which has gradually grown up through years of experience under the guidance of the best engineering and business minds in the automotive and associated industries; the methods employed in establishing standards; and what present indications lead me to believe will become the profession of engineering standardization in the very near future.

Today there is probably no other one branch of the world industries which has developed so tremendously as that of automotive engineering. This development has been not only among those producing the finished automotive apparatus, but among many industries producing raw and semi-finished products such as metals, chemicals, fabrics, parts, special machinery and tools, which enter into the construction or operation of automotive machinery. This development has made evident the necessity for quantity production at low cost per unit which, in turn, has required simplification of design, tooling and methods, or, in other words, the establishment of standards in the drafting room and shop.

Many finished materials and parts are purchased in the open market, and here arises the need for inter-shop and inter-industry standardization to maintain the quality of materials at lowest costs and the interchangeability of parts.

BEGINNING OF AUTOMOTIVE STANDARDIZATION

About the first standard for which a need was felt in the automotive industries was a finer series of screw threads than the Franklin Institute or United States Standard adopted in 1864. Consequently, in 1906, the mechanical branch of the Association of Licensed Automobile Manufacturers adopted what was called the A.L.A.M. screw-thread standard. This series was developed to overcome trouble experienced with screws and bolts becoming loose under the greater vibration met with in automobile engines and also largely because manufacturers had developed and were using special standards of their own. In 1910, the Society of Automobile Engineers became the custodian of A.L.A.M. engineering standardization and established a Standards Committee comprising a few men to consider possibly six important subjects. As the value of standardization became more generally recognized this Standards Committee was extended to include a number of groups, each under its own chairman, to deal with subjects such as carbureter fittings, steel specifications, and broached fittings. In 1917, arrangements were concluded between the Society of Automobile Engineers, the Society of Aeronautical Engineers, the National Gas Engine Association and the marine and tractor interests, whereby the Society of Automotive Engineers became the recognized body for establishing automotive engineering standards. At this time the name of the Society was changed. The word "Automobile" became Automotive," to designate appropriately the work within its scope.

This amalgamation necessitated a still further development of the S.A.E. Standards Committee and permanent Aeronautic, Tractor, Stationary Engine and Lighting Plant, Marine and Motorcycle Divisions were formed. In 1919, the Standards Committee comprised 199 members grouped into 17 divisions. During the year, 64 reports were submitted and adopted by the Society. This year there are 246 members grouped into 24 divisions. There are now nearly 300 standards and recommended practices which have been adopted by the Society and published in the S.A.E. HANDBOOK. As a result of the growth of the isolated electric-lighting-plant industry, a separate division was formed Jan. 1, 1920, to consider the problems peculiar to it.

The organization and procedure of the Standards Committee is, of course, under the general supervision of the President of the Society. The Council of the Society approves the personnel of the Standards Committee and assigns to the several divisions such new work as is considered proper. The Standards Committee is presided over by a chairman who is in cooperation with the General Manager of the Society and the Standards Manager, the two latter being located at the Society offices. Each division of the Standards Committee operates under its own chairman and considers matters coming within its particular sphere of work. As a rule, when important subects are to be considered, a subdivision is appointed; its chairman is a member of the division and the other members are selected from the division or from the industries at large, to secure the assistance of the best-qualified men in that particular field. In selecting members of the Standards Committee, great importance is placed on obtaining men of broad experience and, so far as possible, familiarity with standards work. Many of them naturally come from the companies longer established and better known, but these men are, however, selected more for their personal qualifications than because of the company they may represent.

CLASSES OF S. A. E. STANDARDS

Standards may be defined as generally recognized, carefully correlated, routine engineering specifications for well-defined materials, dimensioning, methods or processes which are accepted and practised by the industries to which they apply. The S.A.E. standardization work is grouped into three general classes; S.A.E. Standards, Recommended Practices and general information. Standards include such specifications as have become more or less permanent through sound and long-established engineering practice. Recommended practices include subjects which have not at the time become well established, but for which a definite practice is desired. General information includes specific information of sufficient value to warrant its publication in the S. A. E. HANDBOOK, and usually has a bearing on a standard or recommended practice. Such subjects for general information are prepared by the divisions of the Standards Committee and are regularly considered by the Standards Committee and the Society at the semi-annual meetings, but are not officially adopted specifications.

Authentic standards must be formulated from data and other existing information furnished by the indus-

[1]Paper presented at the S. A. E. Session of the annual convention of the National Gas Engine Association, Chicago, Sept. 2, 1920.
[2]M. S. A. E.—Standards manager, Society of Automotive Engineers, Inc., New York City.

tries to a relatively small group of men sufficiently experienced in such work to analyze them and bring, out of the mass experience of many, a well-defined engineering specification. If this process is not carefully guarded, the resulting standard will be a paper one only. Much valuable time will thus be lost directly, by having absorbed the time that might have been profitably spent in some other endeavor. The success of S. A. E. standardization is attributable very largely to the observance of the foregoing conditions and to the fact that the work accomplished is of sound, practical nature, presented in such form as to be readily used by the men in the drafting room and shop in their every-day work. It also simplifies much of the work in the purchasing department and leaves the directing engineers free to devote time to more valuable work which would otherwise be required in the preparation of routine details. Much has already been accomplished, by reason of proper standardization, toward the reduction of variations in many specifications such as those for the steels, spark-plugs, many types of fittings and methods of manufacturing, testing and inspecting materials. Advantage has also accrued to those commonly referred to as the service man and his customers, by reducing the number of spare parts for replacements and repairs which have previously been different enough in design to necessitate carrying duplicate stock because of non-interchangeability.

Routine in Establishing Standards

The selection of subjects to be considered for standardization is also important. As a rule, they are scheduled at the request or suggestion of an authority in an industry which will be directly affected. They are then studied with relation to susceptibility of standardization, the limiting features within which standardization can be accomplished and the probable requirements of the industries which will use the standard. Susceptibility to standardization means that the problem must be of an engineering nature and not a commercial exploitation. The limitations are usually those involving the quantity and quality of materials, the dimensioning of parts making for interchangeability and approved methods of procedure. The suggested subject is referred to the Council of the Society for approval and assigment to the proper division of the Standards Committee. If the subject is involved, it is first considered by the members of the division to which it has been assigned and a general plan established outlining the features the standard should embody and what formulative procedure should be followed. The industries are then circularized for data representing current practice and suggestions for consideration by the division. A tentative proposal is then prepared by the division and circularized for approval or constructive criticism. If, as a result, extensive changes are made by the division, the revised proposal is circularized before it is again submitted to the Standards Committee and the Society.

The Standards Committee as a whole meets twice a year to pass upon the reports submitted by the several divisions. These meetings are open to the Society members, their guests and representatives of companies that may be interested in the reports submitted. The reports are discussed and either approved in the original or an amended form. In case of disapproval the report is referred back to the division submitting it for further consideration and presentation at a subsequent Standards Committee meeting. After Standards Committee approval, the reports go to the Council and the Society in meeting assembled. There they may be amended, but they are usually approved as submitted. Reports may, however, be referred back to the division at either of these meetings. In the majority of cases reports are approved almost unanimously, but where there is a divided opinion the majority rules. After approval by the Standards Committee, Council and Society meeting, the reports are submitted to the voting members of the Society for approval by letter ballot, before they can become official S. A. E. Standards or Recommended Practices. By the time reports have reached this ballot they have been so thoroughly considered by such a large number of interests that the percentage of negative votes is negligible.

The time required to develop a standard varies from a few weeks to in some cases a number of years, depending upon the conditions encountered. A large amount of office work is required in corresponding with the industries and members of the divisions, arranging meetings, keeping records and maintaining the S. A. E. HANDBOOK. One of the greatest difficulties is to get a sufficient percentage of replies, to inquiries for data or the approval of tentative proposals, to represent the opinions and practices of the industries adequately. Much time and unnecessary labor will be saved in all work of standardization if prompt replies are made to such correspondence.

After the work has reached this stage the most important phases of standardization remain, those of publication and distribution. It is essential that all standards be published in a clear, concise and uniform manner. This was recognized in the beginning by the pioneer members of the Society and its Standards Committee and the present well-known loose-leaf S. A. E. HANDBOOK has proved the wisdom of selecting this form of publication. Little need be said beyond the fact that clear drawings in ample detail with tables and notes are used to set forth the standards and recommended practices. A complete set of all these standards goes to all members of the Society and includes the new and revised standards issued twice a year. The complete Handbook is available to non-members of the Society at a nominal cost and a single copy of any standard can be obtained upon request to the Society. The standards are not copyrighted by the Society and are free for reproduction in any technical or commercial publication, with the simple qualification that the Society be given due credit. Standards and recommended practices are from time to time reconsidered and revised. The procedure is the same as when the subjects were originally considered. It is important to note in this connection that when any extensive operation which involves a standard is contemplated, such as tooling, it is well to ascertain whether that standard has been revised or is under reconsideration.

American Engineering Standards Committee

The work of engineering standardization has received such broad recognition that a national organization, the American Engineering Standards Committee, has been formed for the correlation of all branches of engineering standardization in America, and to establish a suitable medium for the adoption and promulgation of international standards. The committee is constituted of the principal national engineering societies and a number of governmental departments and bureaus. Each of these is entitled to representation on the main committee of the American Engineering Standards Committee. The member societies can submit their respective standards for approval by the committee as American Engineering

Standards. When this is done, the society inaugurating such action becomes sponsor for that standard and can request that other societies or governmental departments become joint sponsors. Upon designation, the sponsor societies appoint representatives to serve on a Sectional Committee, such appointees to be selected preferably from among the members of the societies. When standards are of an engineering character, the personnel of the Sectional Committee is selected to represent three groups; the manufacturers, the users and general engineering interests.

The usual procedure of the Sectional Committee, in considering a proposal for an American Engineering Standard, is to review the work done by the society in which the standard originated and to correlate it with similar work which may have been done by other organizations. If it is evidenced that revision of the standard is necessary or advisable, such revisions are referred back to the sponsor society or societies for further consideration and approval by those societies in accordance with their regular procedure. It is then submitted to the main committee of the American Engineering Standards Committee for approval as an American Engineering Standard. The "approval" of a standard by the committee does not mean that this committee has itself worked out and approved each detail, but rather that the work has been done by one or more sponsor bodies whose organization, experience and standing insure best American engineering practice. When subjects are under consideration by the Sectional Committee, due consideration is given to the standards or practices of foreign countries and the endeavor is made to correlate them and the American proposal and to establish, so far as possible, international standards.

Another evidence of the recognized importance of engineering standardization is that in a number of our largest industries competent men are being placed in charge of the standardization of shop equipment, methods and products, and to correlate them with standards already established by the engineering societies. It is recognized that this is one of the most efficient means for the conservation of material and effort, not only within their own plants, but in connection with their sources of supply of raw and semi-finished materials. To do this work efficiently, men must be selected who have had considerable engineering experience, and who are familiar with the requirements of design, production and operation. Such men must be executives with ability to solve the many phases of the problems involved.

I believe that with the greater development of standardization, new means will be developed for combating many of the differences and difficulties encountered today in business relations between companies and between executives and their employes. Standardization induces unselfish cooperation and elimination of friction in industrial work and makes possible the reduction in cost of the world's necessities. Standards are truly a commodity, produced and used as an industrial necessity, and their value is measurable in dollars and cents saved by the conservation of materials, time, labor and distribution.

ALCOHOL-FUEL MIXTURES

ALCOHOL-ETHER and alcohol-benzol are the best known of the alcohol mixtures that will first be tried as substitutes for gasoline according to an article appearing in a recent issue of *The Motor*. The former, under the title of Natalite, has recently been subjected to tests by the Admiralty at Haslar. Natalite is a fuel that can be used in an ordinary internal-combustion engine with normal compression, provided the carbureter jet is increased in size. Doubtless it will give still better results in an engine specially designed for it, but in existing engines it can be made to give the same power as gasoline. It exercises no chemical action worth mentioning on metals, although it has a very slight effect on brass and copper, but after the first effect has taken place the action decreases and no serious consequences result. It allows of easy starting from cold; gives good flexibility and does not result in excessive carbonization; neither does it interfere with the work of the lubricating oil. It is a safe fuel, inasmuch as a fire of Natalite can be extinguished by pouring water upon it.

Experiments of London General Omnibus Co.

In the group of alcohol-benzol mixtures, the one which is best known is a 50 per cent mixture of the two fuels that the London General Omnibus Co. has been experimenting with. In an ordinary engine with normal compression the mixture gives some trouble, owing to heavy deposits of an oily carbon nature forming in the induction pipes. When fresh pistons are fitted to increase the compression, and when the inlet pipe is hot-water-jacketed, much better results are secured. Under such conditions the fuel consumption in miles per gallon is just a little inferior to the results obtained with gasoline, but the engine maintains its power much better at low speeds, and there is no sign of knocking when hills are being slowly negotiated. Starting up presents no difficulties. The fuel corrodes iron or copper tanks or pipes. Consequently, these must be coated internally with lead, upon which metal the fuel has no effect. After a considerable amount of running, the inlet-valve pockets get coated with a tarry substance, partially choking the passages. Periodical examination and cleaning are, therefore, necessary. The acceleration and flexibility obtained with the fuel are excellent, and the thermal efficiency is better than with gasoline. Porcelain spark-plugs should be used in preference to mica, the efficiency of the latter being affected by condensation of water from the alcohol. Drain taps are required to run off the water before starting up in the mornings.

From these notes it will be evident that the alcohol-benzol mixture cannot at present be regarded as a satisfactory fuel for ordinary use, because, to get results with it, certain changes in the engine are necessary. Also, its use entails extra work for the owner-driver. There are not the same objections to its general use by larger companies operating commercial vehicles. Its employment by these will leave more gasoline available for private owners and will thus benefit them. Gradually, as more and more fuel alcohol becomes available and the distribution of alcohol fuels becomes complete, modifications in engine design are to be expected, but in the meanwhile the private owner must look rather to alcohol-ether mixtures, and possibly to other alcohol mixtures that have not yet been thoroughly investigated.

According to a report submitted to the State Department by Consul H. C. Claiborne, of London, this substitute fuel which is the best created thus far, costs more to produce than gasoline and is not as good a fuel. The engineers and cooperating scientists of the London General Omnibus Co. report, as the result of an extensive program of experiments, that a given number of British thermal units can be obtained cheaper with gasoline than with the new blend. Using the American cent as a unit of cost, it will pay for 3025 B.t.u. produced with straight-run gasoline as against 2500 B.t.u produced with the alcohol-benzol combination. The cost per mile with the same engine showed a margin in favor of gasoline of 0.4 cents. It was also brought out that a gallon of gasoline would run a motorbus 7.19 miles, while a gallon of the mixture was only good for 6.05 miles. This shows the so-called substitute inferior in every respect.

THE SATURATION POINT

THE automobile business is the largest manufacturing business of finished goods in the country, which means the world. For this year the total volume of the automobile, accessory and supply business will reach $4,400,000,000, of which over $2,000,000,000 will represent passenger cars and trucks.

There is in use now one car for approximately every 13 persons in the United States; as compared with one for every 2182 persons in the rest of the world, 268 in England, 402 in France, 684 in Germany, and 5300 in Russia.

Exportation in the future is in large part the answer to the saturation ghost. Europe has 449,000,000 people and only 437,000 automobiles. If Europe in the constructive years to come will absorb one car to every 50 persons, which is about one-fifth the number of cars in use per capita in the United States, it is obvious that a large number of cars will be required. If the same proportion of cars per person as is now in operation in Iowa, nearly one car per family, were sold in the rest of the United States, clearly many more automobiles would be needed. It is estimated that 45 per cent of the automobiles sold in this country are bought by farmers and small-town inhabitants. The average life of a car being 5 years, the car replacement business alone is of course large.

Vice-President Roberts of the National City Bank of New York has observed that if, as we all hope, by invention and improved methods generally, industry constantly becomes more efficient and the living conditions of the masses improve, the automobile business will, of course, be correspondingly benefited.

In Newark, N. J., over 30,000,000 passengers were carried by motorbuses in 1919. There are about 800,000 trucks in operation in the United States, hauling an average of 4½ tons per day each, or 3,600,000 tons per day, or 360,000,000 tons per year. It is stated that railroad locomotives haul 2,400,000,000 tons per year. It is figured that the average ton-mile cost of motor-truck haulage is 18 cents, as against 0.96 cents by railroad locomotive, and 24 cents by horse. The railroad terminal charges are, of course, large; and time is saved by the motor truck. It is said that truck haulage has released 3,600,000 horses for use for various other purposes in the United States.

No fewer than 25,324,652 shares in nine automobile stocks were traded in during 1919; as against 12,800,086 shares of nine leading railroad companies.

The automobile accessory and supply business, including tires, gasoline and oil, has reached a volume greater than that of the automobile business itself. About $300 is spent by the average car user each year for accessories, supplies, replacements and repairs.

When the so-called saturation point, if there is such a thing, arrives, the world market for tractors, lighting plants and other engines will have been developed. The tropical and subtropical zones of the globe, containing about half of the world's population and the most fertile soil, produce about 6 per cent of the world's food, largely because of the impossibility, on account of the heat, of employing either man or beast for intensive cultivation on a large scale.—J. G. Frederick in *World's Work*.

INLET MANIFOLD CONDENSATION

IT is necessary to remember that, usually, the air, at normal temperatures, contains a certain amount of water. This is in the form of vapor, and, obviously, it takes a definite amount of heat to keep the water in this vaporized state; in fact, there is always a tendency to strike a balance between temperature and the amount of water held in suspension by the air.

Any reduction in the air temperature causes the balance to be upset and, consequently, the air gives up an amount of moisture proportionate to the decrease in temperature. From this it will be clear that condensation can only occur when the moist air is brought into contact with other air or a material which is at a lower temperature than itself.

Reduction in pressure within the induction manifold causes a lowering of temperature of the charge passing through, and results in moisture being given up by the charge in the attempt to maintain the balance between temperature and moisture. It is this moisture which is given up by the rarefied charge that settles like dew upon the various internal surfaces of the induction system.

Obviously, the low temperature of the charge passing through the induction manifold causes the metal of the manifold to become very cold. This chilling of the metal is assisted by the very cold moisture that is condensing on the inner surface. The air surrounding the induction system is, under these circumstances, at a higher temperature than the cold metal of the manifold, and the air in contact with the manifold must therefore be chilled.

Although heat is given up from the outer air to the manifold, and this heat tends to improve matters within the manifold, unless the heat passing inward is sufficient to balance the heat being taken from the internal surface, condensation will increase inside the manifold. This is because the condensation at the two surfaces is the result of entirely different causes.

Condensation depends upon many variable factors, and the conditions causing it are different with various sizes and types of engine and at different speeds of the same engine; and it occurs over a rather wide range of low temperatures. Again, the amount of moisture in the air has a very great effect upon the amount of moisture deposited. For this reason, although condensation is a very sure symptom of low-temperature trouble in connection with carburetion, the indication is not very reliable as regards its amount.

The matter of "lagging" the manifold deserves a discussion by itself; it may be said here, however, that while lagging is beneficial in some cases, it is positively harmful in others. For instance, in a case where no muff is employed and condensation is caused by heat being given up, with beneficial results, from the outer air to the manifold, lagging would merely prevent this beneficial flow of heat inward. From the foregoing it will be clear that in the matter of condensation, removal of the symptoms is very different from the removal of the trouble.—H. G. Harley in *The Motor*.

EFFECTS OF THE NATURE OF RADIATOR COOLING SURFACE

REPORT No. 87 of the National Advisory Committee for Aeronautics discusses the effects of roughness, smoothness and cleanness of the cooling surfaces on the performance of aeronautic radiators, as shown by experimental work, with different conditions of surface on (*a*) heat transfer from a single brass tube and from a radiator, (*b*) pressure drop in an airstream in a single brass tube and in a radiator, (*c*) head resistance of a radiator and (*d*) flow of air through a radiator. It is shown that while smooth surfaces are better than rough, those usually found in commercial radiators do not differ enough to show any marked effect on performance, provided the surfaces are kept clean. The conclusions reached in the report are, of course, equally applicable to radiators for various other automotive uses. A copy of this report can be obtained upon request from the National Advisory Committee for Aeronautics, Washington.

German Airships

THE German Bodensee and the Nordstern dirigibles, and the L 70, the latest type of dirigible built by the Zeppelein organization for the German Navy Department, have frames made entirely of duralumin. The transverse rings of these dirigibles are of polygonal shape. The Bodensee and Nordstern have 17 sides for each polygonal ring, and the L 70, 25 sides. The distance between the consecutive rings of all these dirigibles is 5 m. (16.5 ft.). The gas compartments are 15 m. (49.3 ft.) long in the L 70, and 10 m. (32.8 ft.) long in the Bodensee and the Nordstern. The number of gas compartments in the L 70 is 16, and there are 12 in the Bodensee and the Nordstern. At the end of every gas compartment, metallic cables are diametrically stretched across the ring, so as to form a dividing wall between the two adjacent compartments. A gangway extends from one end of the ship to the other, 1 ft. above the lower sides of these polygonal rings, so that it is possible to walk across it inside the envelope. At a height of about 2 m. (6.55 ft.) above this gangway, a rigid beam, supported by trestles located in the same plane of each ring, and having the form of an isosceles triangle, extends longitudinally, the beam being fastened to the vortex of the triangles.

Water and gas tanks are located all along the ship, on both sides of the gangway, and there are also swinging chairs for the crew. In the L 70, in the center of the ship, space is provided inside the envelope for a table and chairs for the crew when off duty. From this gangway admission is had to the various nacelles by a ladder of rather ingenious design. One of the two side-pieces of this ladder is stationary in a vertical position, the rungs being riveted at each end to the side-pieces so that they can rotate about the pivots to which they are attached at the stationary side. When the ladder is not in use, the mobile side is lifted up and the rungs are thus folded up, taking a vertical position. When the ladder is thus folded, the two sides take the shape of a vertical strut of streamline shape.

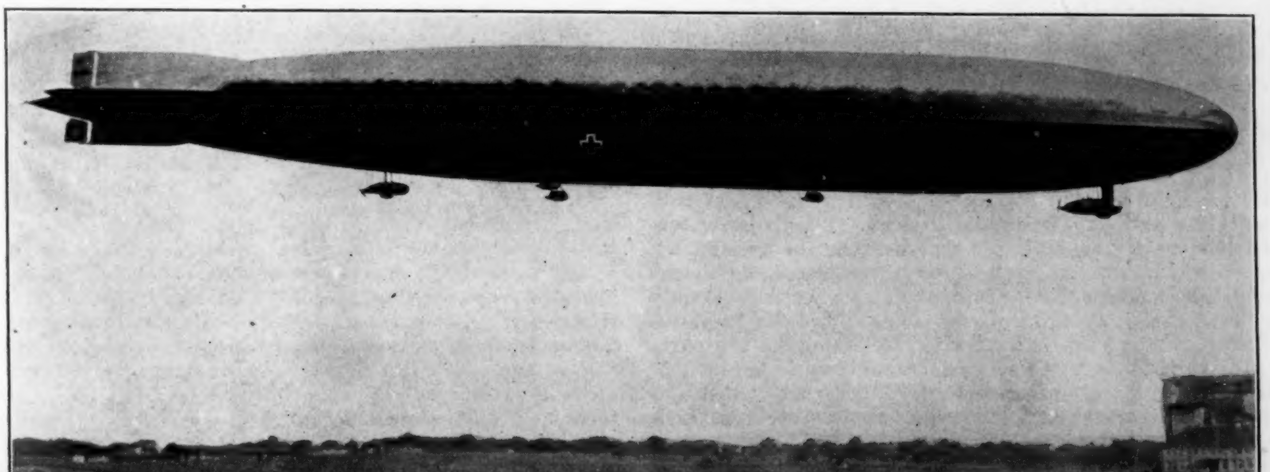
Another interesting point of design is found in the front part of the nacelles, where the radiators of the engine are installed. This front end of the nacelles is masked like a helmet of the Middle Ages. An upper and a lower shield can be lifted so as to expose the radiator inside, or can be partly or entirely closed, thus regulating the draft of air through the radiator and decreasing the air resistance by closing up the mask altogether in front of the radiator when the engine is not used. Six Maybach 260-hp. engines are provided; two on each side and one at each end of the ship. The nacelles containing the end engines are on the ground level when the ship is on the ground; the lateral nacelles are located above the ground-line.

The diameter of the propellers of the lateral engines is 3.2 m. (10.5 ft.). The diameter of the propeller of the end machines is 5.1 m. (16.7 ft.). The nacelle on the front of the ship contains not only the engine but also the commander's cabin, where the navigating instruments and signaling devices are kept and the wireless station also is located. The rudders can be maneuvered through the commander's cabin, or from an auxiliary post inside the envelope, in case the main post should become disabled.

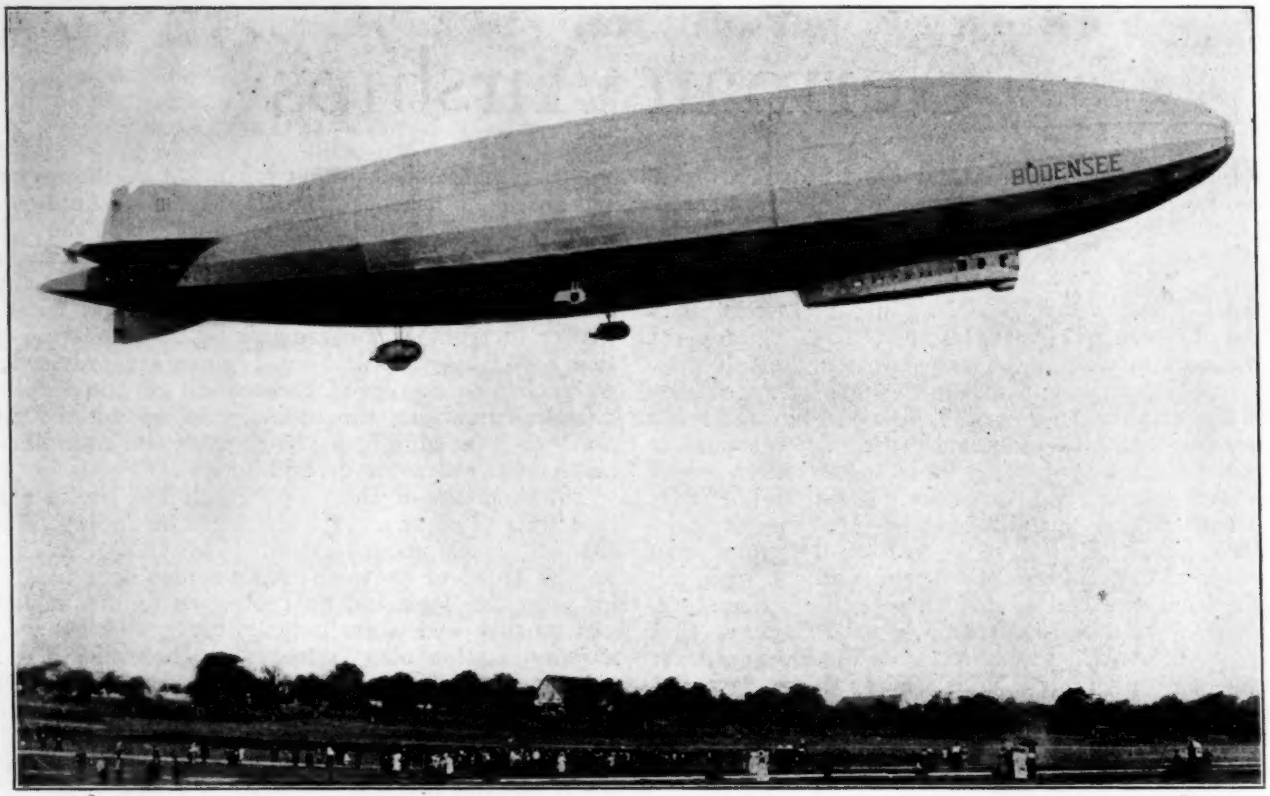
The accompanying table gives general data regarding the L 70 class dirigible.

Maximum diameter	24.0 m. (79 ft.)
Length	226.5 m. (745 ft.)
Cubic contents	68,500 cu. m. (242,000 cu. ft.)
Useful load	52,000 kg. (57½ tons)
Number of men in crew	20
Maximum speed	135 km. per hr. (83¾ m.p.h.)
Maximum weight of gasoline carried	40,000 kg. (44 tons)
Time of flight at maximum speed with maximum weight of gasoline and no wind	134 hr.

The Bodensee contained originally 20,000 cu. m. (71,200 cu. ft.) and was 120.8 m. (396 ft.) long. A length of 10 m. (33 ft.) was added right in the center, and the airship has now a content of 23,000 cu. m. (81,400 cu. ft.). The maximum diameter is 18.7 m. (61½ ft.). It has four Maybach 220-hp. engines, one on



THE L 70—THE LATEST PRODUCT OF THE ZEPPELIN SHOPS



THE GERMAN DIRIGIBLE BODENSEE

each side, and two on the rear end mounted on the same propeller-shaft. It has three propellers in all, the lateral ones being 3.2 m. (10.5 ft.), and the rear one 5.1 m. (16.7 ft.) in diameter. There are auxiliary posts inside the envelope, as in the L 70, for maneuvering the rudders in case the main post should be disabled.

At the lower front end of the airship a cabin is provided for 20 passengers. This cabin is divided into several compartments; the front one is reserved for the commander of the ship, and the navigating instruments and signalling apparatus are installed there. Right behind this compartment there is a second one for the wireless plant. A third small compartment comes next, where a kitchenette and a lavatory are to be found. The fourth and last compartment is reserved for the passengers, who are seated in two rows on each side of the cabin and can look out through windows.

Under average conditions the speed of the airship is from 130 to 140 km. per hr. (81.5 to 87 m.p.h.). The gasoline on board is sufficient to cover a distance of 1500 km. (930 miles). The airship has been flown between Friedrichshafen and Berlin, a distance of about 600 km. (370 miles), the price charged for each passeners' cabin, where accommodation is provided for 30 pas- in October and November 1919. It has been flown also between Berlin and Stockholm, about 620 km. (384 miles), the price charged per passenger being 300 Swedish crowns. Each passenger was allowed 10 kg. (44 lb.) of baggage free of charge, excess baggage being charged on the basis of 5 marks for every kilo above 10. This airship has not been flown since last November.

The Nordstern is a sister-ship of the Bodensee. Its dimensions are exactly the same, except for the passengers' cabin, where accommodation is provided for 30 passengers.—Communicated by National Advisory Committee for Aeronautics.

HOW CAN WE INCREASE PRODUCTION?

THE basis of modern production, with respect to both machines and men, is standardization. The Swiss watchmaker 100 years ago built his watch from the ground up, fitting each part to the parts already completed, as a carpenter builds a house. He never made two watches exactly alike. In America we make our $1 watches and our $2 alarm clocks with dies and jigs and fixtures; we stamp out the parts on power presses or machine them in automatic screw machines, so that part 106 always fits part 105 exactly, although the men who make the two parts may never have seen each other and may not speak the same language. We, as a nation, are committed to the principle of mass production; and while we may deplore the vanishing of the skilled craftsman of the olden days, very few will seriously suggest a return to the method of manufacture formerly in vogue.

However, we do not stop with standardizing machine operations. We also standardize the operations of the men. The motion-study expert tells us that practically every man wastes a large percentage of his time and effort in even the simplest operation; that a dozen skilled mechanics will do the same thing in a dozen different ways, all of them wrong. So the motion-study expert determines the one best way to do a job, and in one case after another we find that by following his method we not only increase production but we decrease fatigue. While so-called "efficiency engineering," like other pioneer movements, has suffered from the pretensions of quacks, there can be no serious question that modern industry demands the elimination of lost motion and the standardization, so far as is practicable, of every job in the plant.—Sidney J. Williams at National Safety Council meeting.

Stellite and Stainless Steel[1]

By Elwood Haynes[2]

THE three metals, iron, nickel and cobalt, are termed by chemists the metals of the iron group. The reason for classifying them thus is that their properties are all similar. All of them are distinctly malleable and distinctly magnetic, and possess high tensile strength and high moduli of elasticity. When pure, they take a high polish and show a distinct metallic luster.

They also resemble one another in their chemical properties. Each is readily soluble in nitric acid; each forms a monoxide with oxygen, as FeO, NiO and CoO; and each also forms a sesqui-oxide, Fe_2O_3, Ni_2O_3 and Co_2O_3. Aqueous solutions of their chlorides, when evaporated to dryness, are transformed into oxides, which are all readily reduced by either carbon monoxide or hydrogen. Their melting points and atomic weights coincide closely; the atomic weight of iron is 56 and those of cobalt and nickel approximate 59. When solutions of cobalt and nickel are mixed, it is difficult to separate the metals one from the other, owing to the fact that their behavior under most precipitants is practically the same.

In 1899 I produced an alloy consisting of practically pure nickel and pure chromium, by heating their mixed oxides with aluminum. This alloy when polished retained its luster even in the atmosphere of a chemical laboratory, and proved to be practically insoluble in nitric acid, even when boiling. It is also malleable when cold, and under proper annealing can be worked into sheets and wire. Shortly afterward, an alloy of cobalt and chromium was produced. This not only showed the same untarnishable properties as the nickel-chromium alloy, but possessed much greater hardness. The alloy could not be worked to any extent cold, but was found to be malleable at a bright orange heat. It was not until 1906 that the alloy was produced in sufficient quantity to determine its properties fully. In 1909 a cutting blade was made of the alloy, which took an edge comparable to that of tempered steel. Later, tungsten or molybdenum was added, and an alloy was thus produced which was sufficiently hard to turn iron and steel on the lathe. Later experiments demonstrated that such alloys, when properly formed, would scratch any steel, and would stand up under much higher speeds on the lathe than the best high-speed steel tools.

Generally speaking, the cobalt-chromium alloys possess certain distinctive properties. They are untarnishable under all atmospheric conditions, immune to nearly all chemical reagents, possess great hardness and retain their hardness up to visible redness. Some of the stellite articles for ordinary use are formed from alloys of cobalt and chromium only. This alloy answers well for table knives, spoons, and the like. The harder edged tools, such as pocket knives and surgical instruments, contain in addition to cobalt and chromium a certain amount of tungsten to give them greater hardness. In other instances, a certain amount of iron is introduced into the alloy to soften it so that it can be more readily worked. Such articles include table-knife blades, pocket-knife handles and certain dental instruments.

When iron is added to this alloy, the resulting mixture is termed Festel metal. This easily workable alloy is well adapted to the manufacture of fine door latches and knobs and high-class sanitary fittings for bathrooms and lavatories. It is not malleable except at a bright red heat, but when a certain amount of nickel is added it can be worked cold on the lathe or under the file. By suitable means it can be given a beautiful stippled surface resembling that of frosted silver, and it retains its luster under all conditions.

Some of the later stellite alloys have shown remarkable resistance to chemical reagents. One of these, possessing high chromium, takes a magnificent polish resembling that of burnished silver. This alloy retains its luster in boiling aqua regia, and is not affected in the slightest degree after immersion in that liquid for a period of 14 days. It is slowly attacked by cold hydrochloric acid, and is nearly immune to the same acid in the diluted form. It is strictly immune to nitric acid of all strengths. Balance weights have been made of this material which retain their luster under the most trying conditions. They are immune not only to the ordinary fumes of the laboratory, such as hydrochloric acid, ammonium chloride, nitric acid and hydrogen sulphide, but even to moist chlorine gas. They present a beautiful appearance and are so hard that their loss from ordinary wear will be perhaps unweighable for several years. There seems to be no good reason why they would not answer equally as well as the more expensive platino-iridium alloys for standard weights and measures.

Experimental Alloys

In 1911 I made some experiments on alloys of iron and chromium with a view to ascertaining definitely their properties. I find from my notes of Nov. 15, 1911, that I had known for some time that chromium, when added to iron or steel, influences or modifies their properties in a marked degree. I was then engaged in gaining a definite knowledge of the effect of chromium on the resistance of steel and iron to chemical and atmospheric influences, and on the hardness, elasticity and cutting qualities of iron and steel. The preliminary experiments which I had already made along this line indicated that the effect of chromium on iron and steel is much the same as on cobalt and nickel. Table 1 shows these alloys.

TABLE 1—ALLOYS PREPARED TO NOV. 15, 1911

Alloy No.	Iron, per cent	Chromium, per cent	Carbon, per cent
20-C	79.4	20	0.6
15-C	84.4	15	0.6
5-C	95.0	5	....
10-C	90.0	10	....
15-C	85.0	15	....
20-C	80.0	20	....

A number of additional experiments were then made and on April 2, 1912, the result of experiment F-2 was recorded regarding a sample of chrome iron made by melting 100 grams (3.527400 oz.) of granulated iron, 17 grams (0.599658 oz.) of chromium, and 2 grams (0.070548 oz.) of ferrotitanium. The metal fused perfectly and was very fluid. Just before pouring, about 1 gram (0.035274 oz.) of manganese was added. The two bars weighed 118 grams (4.162332 oz.). The 5/16-

[1]Abstract of a paper presented before the Engineers' Society of Western Pennsylvania.
[2]M. S. A. E.—President, Haynes Automobile Co., Kokomo, Ind.

in. square bar was forged into a thin edge, which was hard and elastic.

On April 3, 1912, 100 grams (3.527400 oz.) of iron, 17 grams (0.599658 oz.) of chromium, 2 grams (0.070548 oz.) of ferrotitanium and 3 grams (0.105822 oz.) of calcium carbide were fused in a covered crucible the same as before. The bars weighed 118 grams (4.162332 oz.). The 5/16-in. bar was hammered into a cold chisel which would cut iron and soft steel. It was very difficult to file. It probably contained about 1 per cent carbon. It did not seem to differ much in hardness from the sample F-2. The crucible was deeply eroded inside, which was no doubt due to the lime from the calcium carbide.

On April 3, 1912, experiment H-2 was recorded; 100 grams (3.527400 oz.) of iron, 17 grams (0.599658 oz.) of chromium, 2 grams (0.070548 oz.) of carbon, and 2 grams (0.070548 oz.) of ferrotitanium were fused in a covered clay crucible. The bars were not weighed, but the metal poured clean. The 5/16-in. bar was forged into a cold chisel. It seemed somewhat harder than the preceding one. It forged well, but showed a very small crack at the chisel end, which was ground out before the forging was completed. The chisel showed excellent cutting qualities. It would nick ordinary stellite, with but little effect on the edge. The chisel end was heated to about 800 deg. cent. (1472 deg. fahr.) and quenched in water. This seemed to harden it to some extent and when pressed hard it would just scratch glass. It took a fine polish but showed a rather dark color. It was not acted upon by cold nitric acid, either strong or dilute, and the acid showed only a slight residue when evaporated to dryness on the surface of the metal.

On April 4, 1912, 80 grams (2.821920 oz.) of iron, 15 grams (0.529110 oz.) of chromium, 4.5 grams (0.158733 oz.) of molybdenum, and 2 grams (0.070548 oz.) of ferrotitanium were melted in a covered crucible. The 5/16-in. bar was forged to a cold-chisel edge. It would cut nails and the like very well. It seemed also to harden considerably when heated to an orange color and dipped into water. It was afterward made into a wood chisel which took a keen edge and showed fine cutting qualities.

April 8, 1912, two ½-in. square x 11-in. bars were cast; one was from mixture F-2 and one from mixture H-2. Each bar was manufactured into boring bits by the Rockford Bit Works. These bits were ½ in. in diameter and about 10 in. long. Just before finishing they were annealed in lead, which rendered them sufficiently soft to be filed. They were afterward reheated and allowed to cool in the air. They then became so hard that a file had but little effect upon them. They would bore wood fully as well if not better than an ordinary bit. They held their luster in the air under all conditions.

The discoveries rest not on the possibility of adding other elements to the steel which may render it more or less immune to corrosion, or more easily or less easily workable, but upon the fact that immune chromium steels must contain more than 8 per cent of chromium, although, for certain purposes, they may contain much more than that amount, even up to 60 per cent; that such steels are distinctly workable and useful, whether subjected to heat-treatment or not; and that the proportion of carbon can be raised as high as 2 per cent without interfering materially with the untarnishing qualities of the alloy, although such alloys are, generally speaking, more easily worked if the carbon is below 1 per cent.

About two or three years after I made the discoveries mentioned, Harry Brearley, of Sheffield, England, discovered practically the same properties in chromium steel. I am practically certain that his discovery was made independently of any of my own discoveries.

Constituents, Characteristics and Uses

The following metals can be added to stainless or rustless steel, some of which may contribute slight benefit, while others may be slightly detrimental: nickel, cobalt, vanadium, silicon, boron, tungsten, molybdenum, titanium, tantalum, etc. It is evident that an indefinite number of alloys could be thus formed, some with and some without the above elements, but none would be stainless unless it contained the proper amount of chromium, which is the essential element to be added to nickel, cobalt, or iron to produce a stainless alloy.

Stainless or rustless steel consists essentially of an alloy of iron and chromium containing usually from 0.1 to 1 per cent of carbon, although the latter element may be present up to nearly 2 per cent without interfering seriously with the working qualities of the steel. Owing to the high percentage of chromium and its tendency to oxidize at the melting point, even in the presence of carbon, it has been found advisable to melt the steel either in crucibles or the electric furnace. After melting, the metal can be poured into ingot molds in the usual manner and the ingots thus obtained can be forged or rolled into bars or sheets. If the ingots are of comparatively small size, they will be found to be very hard after casting, especially if they have been stripped hot and allowed to cool rather rapidly in the air. Indeed, small bars thus produced are likely to be almost file-hard.

If a small piece of steel thus produced be placed in a beaker with a piece of ordinary steel and covered with nitric acid, the ordinary steel will be dissolved with great violence, while the chromium steel will remain utterly unchanged, thus proving that its immune qualities are primarily due to its composition. This is true whether the steel contains large or only minute quantities of carbon. Cold chisels cast in iron or graphite ingot molds are sufficiently hard without tempering to cut ordinary iron or steel. By heating cast bars to a bright orange temperature, they can be forged fairly readily into various forms. After the forging is completed, the metal can be allowed to cool in the air, and will be found to possess a remarkably fine grain and good cutting qualities. Quenching in water enhances the hardness to a considerable degree, particularly if the steel contains more than 0.4 per cent of carbon. It is best, however, to use oil for quenching, to avoid local contraction stress in the finished article which might cause it to break under slight shock or jar.

Notwithstanding the comparatively high temperature of working this steel, the bars show almost no scale during the forging operation. When finished they are covered with a blue-black skin consisting of a thin film of oxide. Owing to the absence of deep oxidation and resistance to deformation at comparatively high temperatures, the alloy is admirably suited for casting engine valves, distilling apparatus and many other purposes of a similar nature. When ground and polished, the alloy resists tarnish to a remarkable degree. It is superior in this respect to brass, copper and nickel-plate, and far superior to any other steel yet produced. Axes, hatchets, saws and chisels made from it not only will not rust in the atmosphere, but are unchanged when exposed to salt water or salt air. It will likewise, no doubt, find a large

use in the manufacture of propeller blades for steamers, since its modulus of elasticity is much higher than that of bronze and it resists the action of both fresh and salt water perfectly.

Its great strength and comparatively high elastic limit are likewise in its favor. It will also have a large application in the manufacture of pump rods, cylinder linings, pump valves and the like. The alloy is attacked slowly by dilute or strong sulphuric acid and also by hydrochloric acid, but nitric acid has little or no effect upon the polished surface of the metal. It is likewise unaffected, when properly made, by practically all the fruit acids, including strong vinegar.

The alloy will fill a long-felt want among carpenters and others using wood cutting tools. Its freedom from rust, together with its capability of taking a keen cutting edge, renders it admirably suitable for wood-working tools. When made into auger bits, these have remained bright for years under all sorts of atmospheric influences.

SECURING OIL FROM BITUMINOUS COAL

DR. GEORGE H. ASHLEY, chief of the Topographic and Geological Survey of the Pennsylvania Department of Internal Affairs, predicts that the next 10 years will see a revolution in the use of raw coal and that the oil shales of Pennsylvania will be used extensively in oil recovery. He says that by proper treatment of 100,000,000 of the 180,000,000 tons of bituminous coal mined in that State each year the oil supply could be increased by more than 1,000,000,000 gal. Dr. Ashley believes that the use of oil shales for distillation purposes is an extremely expensive proposition and indicated his belief that this method of procuring oil for the making of gasoline would not be inaugurated unless the retail price of gasoline should reach 50 cents per gal.

The initial production of oil in new wells has been far below the initial production of wells in years gone by Dr. Ashley contended. The increasing costs in machinery and operation and a smaller initial flow taken together with the ever increasing demands for gasoline, he said, are responsible for the higher prices.

In discussing the possibility of securing oil from bituminous coal Dr. Ashley said:

> Today, except for metallurgical purposes, we burn coal in a raw state, wasting, when used for power, from 80 to 95 per cent of the heat and energy in the coal and all of the oil, gas, tar and other by-products, except as they are burned in the fire. It may safely be predicted that the next 10 years will see a revolution in our use of raw coal. Already the by-product coke oven is replacing the old bee-hive oven. The coke is made by the distillation of bituminous coal at a high temperature, around 1200 deg. fahr., the quantity of gas given off is reduced and coal is replaced by a smokeless fuel called in one process "coalite," having the same heating value as an equal weight of coal and oil. A plant operating in England with English coal is reported as obtaining 3 gal. of motor spirits suitable for every purpose for which gasoline is used; 16 gal. of oil similar to crude petroleum which can be used for burning, light, lubricating or for distillation; 7000 cu. ft. of gas, richer in heat and higher in candlepower than ordinary coal gas; 20 lb. of sulphite of ammonia for fertilizing and high explosives, and 1400 lb. of smokeless fuel from 1 ton of coal.

Contrasting these figures with those showing the production from by-product coke ovens now operating in the Pittsburgh district, it should be noted that the coke ovens operating at a high temperature give only 1100 lb. of coke and no oil, but give 300 lb. of tar and only 6½ lb. of ammonia sulphite, 3 gal. of benzol and 7000 cu. ft. of gas.—*Oil Paint and Drug Reporter.*

INSTRUCTORS FOR MOTOR TRANSPORT TRAINING SCHOOL

AN open competitive examination for assistant instructor in the motor transport training schools has been announced by the United States Civil Service Commission. As a result of this examination it is desired to fill 100 or more vacancies in the schools which are maintained by the Motor Transport Corps at Camp Holabird, Baltimore; Camp Jesup, Atlanta; Camp Normoyle, San Antonio, Tex., and Camp Boyd, El Paso, Tex. Instructors for automobile machinists and mechanics and in ignition and carburetion, battery repair and rebuilding, tire repairing and wheel building, blacksmithing and spring making and sheet metal working and radiator repairing are needed to enable proper instruction to be given to the enlisted personnel.

Competitors will be rated as to their education, training and experience upon the sworn statements in their applications and upon corroborative evidence. When filing the applications a written discussion of from 1000 to 2000 words must be submitted upon a topic relating to the occupation in which the applicant desires to become an assistant instructor. Application blanks can be secured from the office of the Commission at Washington or from the secretaries of the United States Civil Service Boards located at Boston, New York City, New Orleans, Honolulu, Philadelphia, Atlanta, Cincinnati, Chicago, St. Paul, Seattle, Wash., San Francisco, St. Louis, and Balboa Heights, Canal Zone, or the chairman of the Porto Rican Civil Service Commission, San Juan, P. R.

TESTS TO CHECK SAFE VEHICLE SPEEDS

THE traffic division of the Detroit Police Department recently conducted an interesting series of tests on several types of passenger cars and trucks to determine the efficiency of their braking systems. These tests proved conclusively, according to the police report, that a speed limit of 10 m. p. h. affords both the driver and the pedestrian maximum protection in both wet and dry weather; that 15 m. p. h. is safe in dry weather but unsatisfactory when the pavements are wet, and that 25 m. p. h. is dangerous regardless of the weather. These conclusions are based entirely upon the efficiency of the brakes and do not, of course, make any allowance for the skill of the driver to think clearly and act promptly in an emergency. For this reason they express an opinion based upon the worst set of conditions.

Seven types of passenger cars tested stopped under 11 ft. at 10 m. p. h. on dry pavement. At 15 m. p. h. they stopped in from 15 to 19 ft. on dry pavement and between 20 and 38 ft. on wet pavement. When driven at 25 m. p. h. they traveled from 72 to 103 ft. on wet pavement before stopping. One car equipped with a four-wheel braking system stopped on wet pavement in 28 ft. when traveling at 17 m. p. h. and in 59 ft. when moving at a speed of 25 m. p. h. On dry pavement it moved only 29 ft. when the brakes were applied after running at 25 m. p. h.—*Michigan Manufacturer and Financial Record.*

Constitutional Amendments Adopted

As a result of the letter ballot cast in connection with the proposed amendments of Sections 10 and 21 of the Constitution, the age at which an applicant cases to be eligible for Junior membership in the Society has been raised from 26 to 30 years, and the annual dues of the Junior grade of membership have been raised from $5 to $10.

These amendments were proposed at the Annual Meeting held at New York City, Jan. 7, 1920. The discussion of them at that time was printed in the April issue of THE JOURNAL, together with the report of the Constitution Committee and written discussion that was subsequently submitted. In accordance with the provisions of C56 of the Constitution of the Society, these amendments were brought up for discussion at the business session of the Semi-Annual Meeting which was held on the evening of June 21, at Ottawa Beach, Mich. The discussion at that meeting was printed in the August issue of THE JOURNAL.

The Sections of the Constitution in their amended form are given in the adjoining column.

C 10 Junior grade shall be composed of persons who at the time of election are under thirty years of age and qualified to fill subordinate engineering positions in the automotive or allied industries, or who are regularly enrolled students at or graduates of a technical school. A Junior member may upon reaching the age of twenty-six and shall upon reaching the age of thirty be transferred to Member or Associate grade, in accordance with the decision of the Council as to which grade his qualifications entitle him.

C 21 The annual dues for membership in each grade and for Student Enrollment shall be as follows:

For Member	$15.00
For Associate	15.00
For Junior	10.00
For Service Member	10.00
For Foreign Member	10.00
For Student Enrollment	3.00
For Departmental Member	None
For one Affiliate Member Representative	15.00
For each additional Affiliate Member Representative	10.00

NOMENCLATURE FOR AERONAUTICS

This nomenclature and list of symbols were approved by the Executive Committee of the National Advisory Committee for Aeronautics, for publication as a technical report on April 1, 1920, on recommendation of the Subcommittee on Aerodynamics. The purpose of the Committee in the preparation and publication of this report, No. 91, is to secure uniformity in the official documents of the Government and, as far as possible, in technical and other commercial publications. This report supersedes all previous publications of the Committee on this subject.

The Subcommittee on Aerodynamics had charge of the preparation of the report. It was materially assisted by the Interdepartmental Conference on Aeronautical Nomenclature and Symbols, organized by the Executive Committee, with the approval of the War and Navy Departments, for the purpose of giving adequate representation to the divisions of the Army Air Service and to the Bureaus of the Navy Department most concerned. The first meeting of the interdepartmental conference was held on Oct. 23, 1919, and the second meeting on Jan. 15, 1920. At the latter meeting this report was unanimously approved and recommended to the Subcommittee on Aerodynamics, with the reservation that stability and powerplant terms be given further and special consideration. The stability terms were accordingly referred for special consideration to E. B. Wilson, J. C. Hunsaker, A. F. Zahm, E. P. Warner and H. Bateman, and the powerplant terms were referred to the Subcommittee on Powerplants for Aircraft. The complete report was adopted by the Subcommittee on Aerodynamics on March 8, 1920, and recommended to the Executive Committee for approval and publication.

A copy of this report can be obtained upon request from the National Advisory Committee for Aeronautics, Washington.

FUEL MIXTURES

An interesting paper, entitled Recent Patents on Mixed Fuels, was read recently by Dr. W. R. Ormandy before the Institution of Petroleum Technologists. The author gave a résumé of patents on fuel mixtures containing alcohol taken out since 1913, the record serving as a guide to the interest taken in the fuel question. The only general deduction is that alcohol in some form will be a constituent of the internal-combustion engine fuel of the future. As an example of one patented fuel mixture enabling ordinary 95 per cent alcohol to mix with paraffin the composition is given as

2 volumes paraffin oil
1 volume gasoline
1 volume 95 per cent alcohol
4 volumes fusel oil or amyl alcohol

The interesting feature in this specification is that alcohol and paraffin will not mix, but the use of an admixing agent such as fusel oil or amyl alcohol enables such mixture to take place. Information was also obtained as to the at one time much talked about fuel known as Natalite, used in South Africa. This consists of alcohol with the addition of from 40 to 60 per cent by weight of ether. The use of ½ per cent of ammonia is claimed to overcome any tendency to corrosion of the cylinder. In a later specification trimethylamine is described as taking the place of ammonia.—*The Motor.*

ENGINEERING STUDENTS ENROLLED

On Dec. 31, 1919, there were 15 institutions of higher education in the United States having over 1000 students enrolled in their engineering courses. According to a report of the Bureau of Education of the Department of the Interior the largest enrollment was 2291 students; the next 1915 and the third 1712. The other 12 engineering schools have enrollments ranging from 1691 down to 1030.

The Gasoline Situation[1]

By R. L. Welch[2]

WE now have about 8,000,000 automobiles going around in this country. We are also turning out a couple of million more per year. All use the ordinary grades of gasoline. Some millions of stationary internal-combustion engines are running. It is apparent that we are going to have from 10,000,000 to 12,000,000, maybe 15,000,000, engines of the ordinary type in the United States using the ordinary grades of gasoline before anybody can do more than think about revolutionizing the engine so as to use an oil which might be classified roughly as a combination of gasoline, kerosene and gas oil. The immediate problem, therefore, is to use refining methods that will make internal-combustion engine fuel out of the largest practicable fraction of crude, and broadly speaking that fraction would exist no longer if we revolutionized the engine. It is easier to "revolutionize" the crude into gasoline by cracking than it will be in the near future to revolutionize the engine, and the revolutionized engine would find no greater supplies of fuel than would the ordinary type. More specifically, we can take an ordinary grade of Mid-Continent crude, get 18 to 25 per cent of gasoline by ordinary refining processes, and then perhaps 15 to 20 per cent of kerosene. Superficially it looks as though you would solve something if you got an engine that would combine these two fuels, especially in view of the fact that kerosene is somewhat cheaper than gasoline. However, the facts are that refining companies with modern processes are getting as much as 50 per cent of gasoline from that Mid-Continent crude by cracking the kerosene fraction. Would a new engine enable those companies to furnish more fuel? Obviously not. My belief is that the oil industry, under the compulsion which is created by the scarcity of gasoline, will develop the cracking processes and efficient refining processes more rapidly than the automotive engineers can possibly be expected to develop their equipment.

Conservation and Supply

What is the cooperation in which the designer of the engine can give the public and the oil industry assistance? This whole thing must be looked after from the aspect of the public at large. Nobody knows how much oil there is in the ground. Opinion is divided. I have seen most of the guesses that have been made on that subject. I have talked with many geologists who adhere to one point of view and many who adhere to another. Some think there is plenty of oil to last man for all the time he will use it. On the other hand, there are people who tell us there is not enough oil to last a generation. I would not give even a qualified opinion upon that question, because I believe there is no information which will enable a man to forecast accurately what the actual oil situation will be; there are too many elements of speculation and of guesswork. Looking at the matter from a common-sense aspect, we have no data at present by which we can prove that the oil resources of the world are boundless.

We are faced with the further fact that the world as a whole is consuming more oil than it is producing. There is a scramble for oil that is unprecedented. We have obligations to the present generation and to future generations in relation to this indispensable product. In my judgment the problem in the use of oil is primarily one of conservation in its use. In England and other European countries the public is not demanding so much of the automobile as we are, but using cars of less horsepower than we are using here; cars which on the whole are more efficient. We should hope that a public demand will come for an automobile or an engine that will be more efficient than those we have been using.

Gasoline was and is cheap. The cost of gasoline has been a negligible factor, comparatively speaking, in the operation of a car. I hope it will remain so. I think the oil industry as a whole hopes it will. But when you take a product that is limited in quantity and has the intrinsic value of gasoline, and indefinitely increase the units of consumption, I do not see how any reasonable man could expect anything but an increase of the price commensurate with the increase in consumption. Figures which illustrate this are familiar. The petroleum situation, so far as it affects the automotive industry, can best be illustrated by reference to a little table showing the production of oil in comparison with the number of automobiles which will use it. Supply and demand are not just a sort of hocus-pocus. They are based on certain hard concrete facts.

Great Drilling Campaign

Gasoline comes out of oil wells drilled in response to a demand for the oil and the offering of a price which will justify the man who owns the production or the prospective production, or the lease upon which he wishes to wildcat, to take a chance to produce that oil. Now who owns the oil production of the United States? Is it owned by any company or any group of companies or any group of related companies? Fortunately, the official statistics upon that proposition are available. The entire so-called Standard group, the Standard Oil Co. of New Jersey and its former subsidiaries, owned, in terms of the volume of production in barrels, 17 per cent of the oil produced in the United States last year. In terms of value, as estimated in the table based upon $1 per 1000 bbl. of production, which is a yardstick which measures the percentage approximately, they owned 13.95 per cent.

You all remember 11-cent gasoline. You remember it with pleasure and regret. You say, "Why have we not got it now?" What happened? In 1913 the producers in the United States drilled approximately 25,000 wells to get oil. The average price paid for crude was 95 cents. That does not look like $3.50 Mid-Continent crude or $6.10 Pennsylvania crude. In 1914 they had a little discouragement. The price fell off to 81 cents on the average, and they drilled only 23,000 wells. However, those wells were especially prolific, and you remember that it was in 1914 and 1915 that the bottom dropped out of the gasoline market and the low prices prevailed. The price of crude oil descended to an average of 64 cents per bbl. In 1915 they only drilled 14,000 wells. Why? It did not pay the producer to drill. The prevailing overproduction was followed by an under-production. Oil went up to $1.10. The next year they drilled 24,000 wells.

[1]Address at S. A. E. session of the annual convention of the National Gas Engine Association, Chicago, Sept. 2, 1920.
[2]General secretary, American Petroleum Institute, New York City.

The increases in the price of petroleum which commenced last November have resulted in the greatest drilling campaign to get oil we have ever known. They have resulted, furthermore, in an unparalleled campaign to import oil. In August the number of new oil wells brought in was 3513, the highest mark in the history of the United States.

Half Billion Barrel 1920 Production

Last year we produced about 377,000,000 bbl. of oil, and imported from Mexico approximately 52,000,000 bbl., making a total of 429,000,000 bbl. I believe that this year we will produce and import in the neighborhood of 500,000,000 to 525,000,000 bbl., possibly more. In terms of production, this great drilling campaign is getting results. We started out about last September to consume more oil than we were producing, and were drawing upon domestic stocks at a great rate. It is cause for congratulation that the official figures for June and July of this year indicate that for the moment at least we have reversed that situation. In January we were producing oil at the rate of 401,000,000 bbl. a year here, and consuming at the rate of 409,000,000. In February the figures were 419,000,000 and 420,000,000; in March 430,000,000 and 439,000,000; in April 443,000,000 and 452,000,000; in May 436,000,000 and 439,000,000. In June we were producing at the rate of 454,000,000 and consuming at the rate of 430,000,000 bbl., and in July producing at the rate of 453,000,000 and consuming at the rate of 437,000,000. Furthermore, the imports from Mexico have been constantly increasing in a degree that is extremely gratifying. If the oil demand of the future is to be met, it is going to be met in response to the ordinary economic law of supply and demand, the price being such that men are going to search for the oil and go out and get it, in Mesopotamia, in Mexico or elsewhere.

We are on the import basis as far as oil is concerned. In 1918 we imported 37,000,000 bbl. from Mexico; in 1919, 52,000,000. From January to July of this year we imported 39,000,000, more than we imported in 1918. It is very significant that in June of this year we imported over 8,000,000 bbl. of oil from Mexico; at an annual rate in excess of 100,000,000 bbl. That is the way the American oil man is trying to solve the fuel situation. Capital to the extent of hundreds of millions of dollars is pouring freely into the oil business from every conceivable source to go out all over the world and find oil. I believe that American ingenuity, capital and brains are going to get the oil.

Decline of Wells

There is another fact to be remembered about oil production. Sometimes a well will flow for a period of years at a practically uniform rate. For example, there are in California many wells that are doing today in volume substantially what they did 10 years ago. On the other hand, there are wells in the Mid-Continent fields that started out with a whoop but shortly dropped to practically nothing.

Stimulation of production is the heart of the present gasoline situation. I am not talking about future generations. If the producers get it into their heads that there will be an over-production of oil, and stop drilling, the effect will be immediate.

The aggregate production of several large oil producers last year was 172,000,000 bbl. Of that production 25 per cent came from wells that were actually drilled last year. With a constantly increasing consumption a very large number of wells must be drilled. Decline in fields is to be considered. Cushing Field made gasoline low-priced. Somebody poked a drill through the earth in the vicinity of Cushing; nobody knew there was a big field there. In a very short time 285,000 bbl. per day was gushing forth. It could not be taken care of. One year later the field was producing only 116,000 bbl. per day despite constant drilling. Two years after the date of the highest production the field was producing only 64,000 bbl. per day.

The highest production of Augusta was 75,000 bbl. A year later it was 25,000 bbl.; two years later 16,000. Another famous field, El Dorado, produced at one time 109,000 bbl. per day. One year later its production was 49,000 bbl. These great fields, which as a whole reached their highest production at 565,000 bbl., descended the first year to 271,000 and the next year to 187,000 bbl. per day. Production of gasoline must be discussed in terms of oil production in the United States and other countries.

World Contest for Oil

The attitude of the American Petroleum Institute is to lay the cards on the table. The policy of the American oil business is to tell the people what is going on. We will try to get the facts as to oil collated and present them to the public.

The war awakened a new realization of the value of oil in the minds of everybody in the world. The control of petroleum has a vital relationship to the development of national power. Great Britain and the other countries are, as they should be, fully awake to the world's necessities for oil, and there is a great commercial contest for the possession of the oil fields, no matter where they are located. There is every indication that we shall continue to be on an import basis. What would we do this year without the 100,000,000 bbl. from Mexico? There is oil in Persia, in Mesopotamia, in Russia. American capital is ready to go into those countries, all that is necessary to that end being assurance that American citizens and property there will have protection. I believe that they will have that protection.

Shale Oil

So far as I know, nobody is producing oil from shale in this country at this time on a commercial basis. A number of companies have claimed to have processes whereby they could do this. You can rest assured that no large oil company in this country is overlooking the importance of this matter.

The deposits of oil shale are believed by those in the oil business to be enormous and inexhaustible. There are other enormous deposits of petroleum besides the shale; great fields of it. But you have the same commercial proposition. There are untold quantities of gold in the sea, but nobody has succeeded in making common property of it.

In 1918, we produced in the United States about 377,000,000 bbl. of oil. We imported from all other countries 39,000,000 bbl. Our exports were gasoline, 8,000,000 bbl.; other naphthas, 5,000,000 bbl. In 1919 we exported 6,000,000 bbl. of gasoline and 2,000,000 bbl. of other naphthas. We imported 52,000,000 bbl. of crude, and a large amount of fuel and gas oil.

Of the world's production of crude petroleum from 1857 to the present time, the United States produced 61 per cent, Russia 25 per cent, Mexico 4 per cent, the Dutch Indies 3 per cent, Roumania 2 per cent and India 1 per cent.

Increasing Efficiency

Kerosene is cheaper at the present moment than gasoline. Therefore, the man who is using kerosene is using a cheaper product. That product can be cracked into gasoline. Kerosene has been advancing in price more rapidly than gasoline for the simple reason that the economic tendency, the two products being identical in terms of refining when you have the proper apparatus, undoubtedly has been and will continue to be to pull that price up to the level of gasoline. Both products should be conserved. I do not want you to get the thought that if, for example, you can develop an engine that will use gasoline, kerosene and gas oil mixed, I would discourage any man from doing it, but to say that he is solving anything so far as the fuel problem is concerned is a superficial analysis of the situation, because those fractions of petroleum are, under improved refining processes, identical in their constituent elements and the necessity for conservation exists in both.

The price of gasoline has not been high enough to cause very many people to make any effort to save it. I want to read some extracts from letters I have received.

> We believe it has been proved that it is not necessary to maintain a large and high-powered car, and consequently an expensive car, to realize comfort, speed and reliability on the road. These qualities are fully met by many of the smaller high-class cars now on the market, with the added feature of fuel and oil economy.
>
> We believe it is possible to design a perfectly satisfactory motor car to meet the most exacting requirements that will obtain 20 to 25 miles per gal., with corresponding oil economy.

I have a number of responses like that from some of the most responsible men in the automotive industry. There does not seem to be any disagreement.

COMING MEETINGS OF THE SOCIETY

Motor Boat Meeting	New York City, Dec. 14, 1920
Annual Meeting	New York City, Jan. 11 to 13, 1921
Chicago Winter Meeting	Chicago, Feb. 2, 1921
Tractor Meeting	Columbus, Ohio, Feb. 10, 1921

THE Meetings Committee has decided upon the dates specified above for meetings of the Society to be held at the places indicated during the weeks of the respective motor boat, automobile and tractor shows. Members expecting to attend the sessions should make early reservations direct with hotels in the cities named.

With respect to the meetings, it is clear that greater and greater demands will be made upon automotive engineers for professional service in the competitive markets of the world. The gatherings of S. A. E. members in national assemblage are not overlooked by keen men as markedly unusual opportunities for preparation in service.

The Meetings Committee is desirous that members submit, in a competitive way, manuscripts on new and fundamentally important automotive engineering facts, for possible presentation at the winter sessions. It is certain that the programs of the meetings will be of extraordinary interest.

The Annual Meeting in New York will be opened by sessions of the Standards Committee on Tuesday, Jan. 11. The Annual Business Session and Election of the Society will be held on the morning of Wednesday, Jan. 12. It is expected that in conjunction with this a technical paper on a timely subject of general interest will be presented.

Recognition of the broad engineering interests of the members has led the committee to arrange for the simultaneous conduct of sessions during some of the periods of the Annual Meeting, on such diversified subjects as body engineering, production and transportation. The program relating to fuel and research will include papers on

Chemical and Physical Phenomena
Related Mechanical Features in Automotive Powerplant Design
Relation of Chassis Design to Fuel Economy

The effort of the committee is to make plain the best perspective views of conspicuous present-day problems in the automotive industry.

At the Hotel Astor, New York City, on Wednesday evening, Jan. 12, there will be festivities emulating the Carnival of January, 1920, in the form of a dance-entertainment. This is the great family and social winter gathering of the S. A. E. There is reason to believe that the immense success of the Carnival will be at least duplicated.

The Annual Dinner will be held at the Hotel Astor on the evening of Thursday, Jan. 13. This will be a house-capacity event as heretofore. The professional phase of the membership will be emphasized.

Motor Boat Meeting

The first of the coming Society events will be the Motor Boat Meeting, at the Automobile Club of America, New York City. A dinner followed by a technical session is scheduled.

Chicago Meeting

The year would not be complete without the interesting and enthusiastic Annual Chicago Meeting. Professional sessions have been arranged for during the morning and afternoon of Wednesday, Feb. 2. In the evening the dinner will be given at the Hotel Morrison.

Tractor Dinner

This year the helpful and entertaining Annual Tractor Dinner will be held at Columbus, Ohio, on Thursday evening, Feb. 10. Matters of economic and technical importance will be discussed by highly qualified men.

MOTOR-TRUCK SERVICE REGULATION

IF motor-truck service is to be regulated it can be of most value by establishing through routes with joint rates and through bills of lading. Through billing would be of great convenience to the interior shipper or merchant, but if through bills of lading are to be granted they should be properly protected. Under the Transportation Act recently enacted Congress gave to the Interstate Commerce Commission increased power in the division of rates. Without just and proper divisions of rates the motor-truck line might find it impossible to survive. In determining the proportion of the joint rates to which the motor-truck line is entitled, the Interstate Commerce Commission or other regulatory body would have to determine the cost of the service rendered by the motor-truck line. But as yet we have not sufficient data to determine such cost; it varies with the character of the road, the type of truck used, the length of the haul and many other elements. Under the Transportation Act the Commission also has the power to fix both the maximum and the minimum rates on the rail haul. Should the regulatory body be given a like power over the charges made by the motor-truck line or should such charges be limited only to their maximum as with water transportation?—John J. Esch.

Automotive Engineering Standardization and Progress[1]

By Coker F. Clarkson[2]

STANDARDIZATION is the codification of the best consensus of opinion as to what should be specified for those items of materials and dimensions which it is clear can be reduced advantageously to common practice. The purpose is, of course, to improve the conditions of manufacture and operation. The draftsman's time is saved and made more efficient. There is established a very helpful esprit de corps as to what can and should be done in the way of standardization. The stocking of materials and many component parts of subassemblies becomes possible, time being again saved. The product is improved in quality both as a whole and in detail. Price always tends to become relatively less. The user can maintain the apparatus he has bought more economically as to time and in a pecuniary way. He gains increased knowledge of and confidence in the manufacturer's product by finding therein detail features of construction which are generally known and accepted as good. This is akin to one of the most potent principles of advertising; a feeling of plausibility and propriety is engendered through the effect of general publicity. Common knowledge of this sort is beneficial in all effective commercial operations.

The world would be in a more deplorable state if it did not have a great mass of what are standards in varying degree, although these are not generally appreciated to be standards in the sense that we are considering them. Among such standards are sizes of wearing apparel and of numberless other commodities that readily come to mind. These are not necessarily standards of a high degree of accuracy, such as standards of units of measurement, time and quantity are supposed to be.

One troublesome misconception of the standards we are discussing is that they are mandatory. Another is that they are manifestos of finality like standards of weight or measure. An automotive engineering standard is a thing that is considered, by men well qualified to judge, good or best for the great bulk of the manufacture in our field, to facilitate quantity production in the way I have indicated. The Society of Automotive Engineers has no way of enforcing the use of its standards except insofar as their merit is weighty. This is as it should be, and for a like reason the S. A. E. standards work has been successful. It has been demonstrated over a period of years that most of the standards can be reduced to practice by the great majority of manufacturers with marked benefit to themselves, as well as their customers; in fact, in all cases where the production is not really inherently special, or on account of large substantially identical previous production not incorporating the currently desirable standards. The latter condition is almost inevitably a matter of the relative importance of the past and the future to the manufacturer.

The Society of Automotive Engineers is not commercial in the sense that it can enforce its standards in an arbitrary way. It is commercial in the sense that its standards are of commercial value. The Society can conduct its activities on a somewhat broader and less partisan basis than a commercial organization. A commercial organization of manufacturers, proceeding as such, without giving effect to engineering questions as such, cannot, on account of competitive sales reasons, get as good results in the formulation of engineering standards as an organization like the Society can. In more than one instance that organization has established standards that have gone into general practice, after the representatives of the manufacturers directly concerned working together, or failing to work together, had been unable to establish them.

Standards should, of course, be canceled or revised when necessary. They should not obviously be promulgated originally unless there is sufficient evidence to assure their holding good for a properly long period of time. But the whole system should be conducted flexibly and not inflexibly.

The more or less chronic stock argument against standardization is that it impedes individual and engineering progress. This is the sort of argument that is legion and perennial in almost every field of endeavor. I believe that no fair-minded man would say that standardization has impeded the progress of the automobile industry. There is every evidence that it has been one of the main reasons for the quantity production in this field, facilitating purchase of materials, improving quality and decreasing the cost of maintenance. Quantity production is clearly not possible without a great degree of standardization of some kind, and the standardization the Society of Automotive Engineers has fostered has surely been most advantageous to the great majority of manufacturers and users in the automotive field. There is a very material saving in the manufacturing cost per car. Screws, taps, dies, spark-plugs, steels and many other materials and parts can be bought at lower prices and for better delivery. The producing companies have saved a large amount of money in lowered material costs and in lessened production complications. There is no doubt that the standards and recommended practices of the Society of Automotive Engineers have been of incalculable benefit to the automotive industry at large. The cost to the consumer of standard gages has been reduced greatly, compared to what it was when gages were made specially to meet customers' requirements. It is stated that 95 per cent of the lock-washers used in automobile fabrication and operation are S. A. E. Standard. These are merely examples of a widespread condition as to S. A. E. Standards and Recommended Practices.

A fundamental maxim of the Society has always been to not endorse or condemn any proprietary article, nor to endeavor to standardize any practice that would impede progress in design. As a class the standards consist of material and mounting-dimension specifications for those things that are essential in the present types of automotive apparatus. Incidentally, it cannot be ignored that the greatest successes have been attained in those automotive fields in which the design of the articles produced has been most conventionalized, conspicuously in the

[1]Address delivered at the S. A. E. session of the annual convention of the National Gas Engine Association, Chicago, Sept. 2, 1920.
[2]M. S. A. E.—General manager, Society of Automotive Engineers, Inc., New York City.

automobile field. Much conventionalization is essential in great commercial success with apparatus individually operated by a large number of people in a mechanical way. The most advanced and efficient apparatus cannot necessarily be operated by the average user. The generally prevalent knowledge of the internal-combustion engine is a principal reason for the success of the vast amount of automotive apparatus in use. Intelligent standardization could not check and can only assist such a condition. There is no trade advantage to any single company in not participating in the establishment and practice of rational standardization. Neither is there any advantage in the way of design.

In England recently there was designed a simple and inexpensive stationary engine for general purposes, such as dynamo driving and farm work, and at the same time to obtain the very high efficiency which had been attained hitherto only in very costly engines, such as those used for aircraft. It is stated that during a 100-hr. run developing 6 hp., at less than 750 r.p.m. governed speed, the fuel consumption was a little over ½ pt. per hp.-hr., most engines of a similar size consuming ¾ pt. per hp.-hr. It was figured that with this type of engine the money saving per year for fuel would be $65 per engine. The engine was single-cylinder, 4 x 6 in. The oil consumed was 0.012 pt. per hp-hr. This performance is decidedly an example of appealing engineering progress. The work of the Society of Automotive Engineers in standardization, research and other respects has been and is primarily such as to encourage such development, and not in the least to impede it. The whole purpose of the Society is to bring about improvement in the entire automotive field, increasing the efficiency of engines and power transmitting devices.

The automotive world is one large growing family, both nationally and internationally, and is making every effort to further and make as effective as possible those phases of efficient production of automotive apparatus of great merit, in which the engineering fraternity takes such a deep interest and which are so essential to the Nation industrially and economically. In worldwide trade it is obvious that the maintenance of standardization which will make possible the interchangeability of many materials, parts and accessories, is economically requisite.

More Miles Per Gallon

ALTHOUGH extra air devices are not to be recommended as the best means of suitably diluting a mixture, they are, in the absence of a properly controlled fuel output, the next best thing, if intelligently used. It is most essential, however, that they fit accurately; otherwise starting and slow-running troubles will surely develop. In the early days of gasoline the gravity and, therefore, the evaporative qualities, were much better than they are now, the difference between the volatility when hot and when cold was consequently much less pronounced, and a jet setting which gave a certain mixture when the engine was first started up did not vary to a great degree when the full working heat had been attained. Now that the gravity has greatly risen a mixture which is correct for a cold engine is much too rich after running for a while. This is not through any fault of the carbureter, but due to a physical property of gasoline by virtue of which the effect of heat on its evaporative properties varies directly with its rise in gravity.

The uninitiated are apt to be deceived by certain correct, but thoroughly indiscreet, statements occasionally made in print by writers of experience to the effect that a cold mixture is more efficient than a hot one. Such remarks apply only to engines of high output, tuned for power regardless of consumption, and are most misleading when interpreted, as they frequently are, as being applicable to ordinary touring conditions. If economy is desired heat is always necessary, regardless of the carbureter fitted.

Gasoline level is another point upon which one hears many and divergent opinions. Here much depends upon the make of carbureter, for some instruments are more affected by level than others, but, broadly speaking, it may be stated that it is better to have a high level and a small jet than vice versa. The reason is that if the induction current should be of an unduly pulsating nature the air and gasoline column inertias are more likely to be interfered with in the latter than in the former case. When the fuel lies deep down in its jet it responds slowly to jerky impulses, and having gathered the necessary momentum to emerge from the spraying orifice, it continues to do so for a certain period after each impulse has ceased, thus lagging behind the air inrush which creates the impulse, and losing the benefit of the accompanying spraying velocity.

Induction Leaks

When the throttle is nearly shut, as in slow running and starting, the actual volume of mixture passing up the induction pipe is small in comparison with that necessary for running the engine when working under load conditions. A degree of air leakage, therefore, which would represent a negligible addition with an open throttle becomes, when idling, a considerable dilution. To cope with this the slow-running supply must be greatly in excess of that which the engine should normally require, and the result is that on opening the throttle this leakage becomes proportionately insignificant and the slow-running jet which was tuned to it becomes relatively in excess.

The most usual causes of leakage are (*a*) imperfect inlet-pipe joints, (*b*) worn inlet valve-stems, (*c*) bad compression owing to defective piston-rings and (*d*) a worn throttle spindle. The first three are easily detected, but the last is much more difficult to determine with certainty, and the methods of locating it vary with each carbureter. The ability of the engine to take a useful spark advance depends upon (*a*) the compression ratio, (*b*) the design of the combustion head and (*c*) freedom from carbon deposit.

The great essential in obtaining thermal efficiency is to be able to use a high compression without introducing those conditions which make for detonation. The most prolific cause for this is local interference with heat radiation and, apart from the question of design, carbon is the most potent agent in producing this trouble, in that the local hot areas resulting from its presence help to raise the temperature of the charge to a degree which it would not ordinarily attain by a legitimate compression ratio. In this way certain parts of the mass of gas are brought above their detonation point and burn suddenly and uselessly with the characteristic noise. The immediate effect of this is that the ignition must be retarded with the result that unless a heavier mixture is used there will be a loss of power and an inclination to overheat. The golden rule is, therefore, to keep the engine clean so that a good spark advance can be given, and take advantage of this, as far as possible, by reducing the fuel consumption.

Factors Controlling Combustion

There are, very broadly speaking, four general factors upon which useful combustion depends; (*a*) the production of a good spray, of correct constitution, and reasonably heated to avoid deposition, (*b*) the elimination of avoidable causes of detonation, such as incorrect ignition timing, carbonization, etc., (*c*) well-designed cams and induction and exhaust systems to reduce to a minimum fuel deposition in the inlet pipe and (*d*) a combustion head of the most advantageous shape to promote a maximum degree of charge whirling and offer the smallest possible area of heat-absorbing surface per weight of charge burnt.

The principal trouble which occurs on failure to carry out the condition called for under (*c*) is periodic blow-back. This can readily be detected, by running the engine slowly, placing the hand near the air intake of the carbureter and suddenly opening the throttle. Pulsations, if present to an appreciable degree, can then be felt on the palm of the hand as the engine picks up, and if the carbureter is of the straight-through type the actual ejection of gasoline will frequently be seen. If the suction noises in the throttle chamber are audible the jerky nature of the sound will show a blow-back to be present without any further test. When this has been established it may be taken that economy is impossible until the causes of the blow-back are removed. It is directly the result of two conducive circumstances, (*a*) the inlet valve remaining open unduly long, and (*b*) the presence of residual pressure in the combustion head at the end of the exhaust stroke. The former is not so frequently met with as the latter, and is not generally in evidence until the closing lag of this exceeds 50 deg. The latter is, however, a very common and seldom recognized cause of fuel waste, and is produced by (*a*) the exhaust valve closing before the upper end of the stroke, (*b*) silencer partly choked, (*c*) exhaust manifold cast in block with the cylinders, (*d*) unduly retarded ignition, and (*e*) excessively weak mixture.

An exhaust closing and inlet lag of 55 deg. will, if the springs are very strong, no doubt improve the power performance at high engine speeds, but as an offset the economy will certainly suffer and the flexibility at ordinary speeds will be adversely affected.

A valve setting in which the overlap is reduced to approximately 5 deg. and the inlet lag to 35 deg. will generally give much better results. Although cutting the upper speed limit down slightly this setting will give more flexibility, better acceleration and probably a much better consumption. It is impossible to more than indicate the best valve setting without having regard to the design of the inlet and exhaust system and the shape of the combustion head. Two things are, however, certain. The exhaust valve must never close on, or before, the top of the stroke, and the inlet, where economy is desired, must never open before top center. To this may be added that only in very exceptional circumstances should the closing lag of this valve be greater than 45 deg. An early closing exhaust produces an invariable blow-back, and a late inlet frequently has this effect. A slight overlap usually improves economy, but a very few degrees of excess will have the opposite effect. The reason an exhaust closing lag is necessary to prevent blow-back is that a slight positive pressure is generally present in the head at the top of the stroke. If the inlet is opened before this has time to disperse it is discharged into the induction pipe, causing the pulsations referred to, but if the valve is allowed to remain open a short time the moving column of gas in the manifold acts like an extractor pump and withdraws a large proportion of it by suction.

The cast-in exhaust manifold involves sharp bends near the valve ports where the velocity is very high, and the action of trying to "bend" the rapidly-moving column causes a great amount of rebound, which, of course, takes the form of back-pressure. For a time this unfortunate practice was very fashionable among engine designers, but in recent models it has almost entirely disappeared. A complete cure does not appear to be possible for engines having back-pressure due to this cause, but a compromise can be effected by fitting a constant vacuum carbureter which damps out the impulses to a certain extent. The effects of weak mixture and late ignition are similar, in that they both produce a retarded flame rate and thus leave a residual pressure. It is most important that there should be an outside exhaust manifold, and, secondly, and almost as important, a heated carbureter. In this connection it must be stated that at the Olympia Show there were no fewer than 11 different makes without any heating whatever. Thirdly, a means of controlling the gasoline feed from the dashboard or, failing that, a well-fitted extra air device of good make is needed. Variable ignition is always advisable, but it must be used intelligently.—L. Mantell in *The Motor*.

STANDARDIZATION ?

THE following list gives some idea of the different kinds of materials necessary to make the DeHaviland-4 plane:

2608	wood parts, only 608 of which are alike in shape
1665	sheet metal parts, of which 1500 differ from each other in shape
20	forgings, of which 20 differ from each other
139	tubes, of which 139 differ from each other
78	castings, of which 78 differ from each other
5335	bolts and machine screws, of which 1500 differ from each other
1589	nuts of 50 different styles
1213	washers of 100 different styles
10,675	wood screws of 150 different shapes and sizes
8609	nails, tacks, etc., of 150 different shapes and sizes
659	wires of 20 different kinds
87	terminal standards of 40 different shapes
750	small metal parts of 300 different shapes
366	pieces of linen, of which 50 are different
12	bearings, of which 1 is different
474	items of equipment, including military equipment, of which 470 are different
343	miscellaneous parts, of which 300 are different

In addition there are needed such articles as bakelite, cellulose fiber, fabrikoid, felt, glass, leather, nigrum, rubber, rawhide and transparent sheets. For one DeHaviland plane 128 yd. of linen, 827⅔ yd. of silk thread, 215 yd. of special cotton tape, 440 yd. of cotton twine and 168 yd. of linen twine are used. Allowances for waste or spoiled material are not included in these figures. Moreover, each plane requires 110 gal. of shellac, varnish and dope. The 2608 pieces of wood include 664 pieces of veneer, 1586 pieces of spruce, 152 pieces of ash, 36 pieces of walnut, 6 pieces of maple, 24 pieces of hickory and 140 optional pieces of different hardwoods.—A. D. Wilt, Jr.

COLLECTIVE BARGAINING

NATURE did not make men alike, nor does she reward them alike when they seek to wrest a living from her. Collective bargaining in whatever form it may appear can hardly comply with natural laws, insofar as it seeks and does

(1) Standardize men
(2) Standardize the returns or earnings of men
(3) Deprive them of their initiative or ambition

The continuity of the race depends upon certain fundamental instincts in the human being, among which are initiative, ambition, desire for ownership in one form or another and individuality. Any scheme of industrial relations which obliterates or limits these human instincts is probably doomed to failure. Nature wrote the first constitution and the first laws, and so far as we know, no one has been able to violate them with impunity.—L. R. Clausen.

AERIAL MAPPING

THE Army Air Service is now cooperating with map-making companies in making detailed maps of the immediate vicinity of Washington. This is another step in proving the reliability and utility of maps made from the air for commercial work. A number of very successful and complete air maps have been made in the past and following the success of each venture larger projects are undertaken. Important camera developments for this work, together with other special airship equipment, are now having the attention of the Air Service.

Some cooperation has been given to the Coast and Geodetic Survey and it is contemplated that aerial photography will eventually be a considerable help in developing the complete topographic map of the States.

Duralumin[1]

THE use of duralumin in the construction of aircraft renders an account of the properties of this material desirable especially with reference to its working qualities as developed by experience.

Duralumin is made in various compositions and has, with the exception of small quantities of impurities, the following composition:

	Per cent
Aluminum	95.5 to 93.2
Magnesium	0.5
Copper	3.5 to 5.5
Manganese	0.5 to 0.8

Lead, tin and zinc which, as is well known, have an unfavorable influence upon the permanence of aluminum alloys are not found in duralumin. The specific gravity of duralumin varies according to composition and hardness from 2.75 to 2.84. The melting point is about 650 deg. cent. (1202 deg. fahr.).

Working of the Alloy

Like other metals, duralumin can be rolled into plates and shapes and behaves in a similar manner, in that the elongation decreases as the hardness of rolling increases. Tube blanks, however, can be made only by pressing and not by the oblique rolling method.

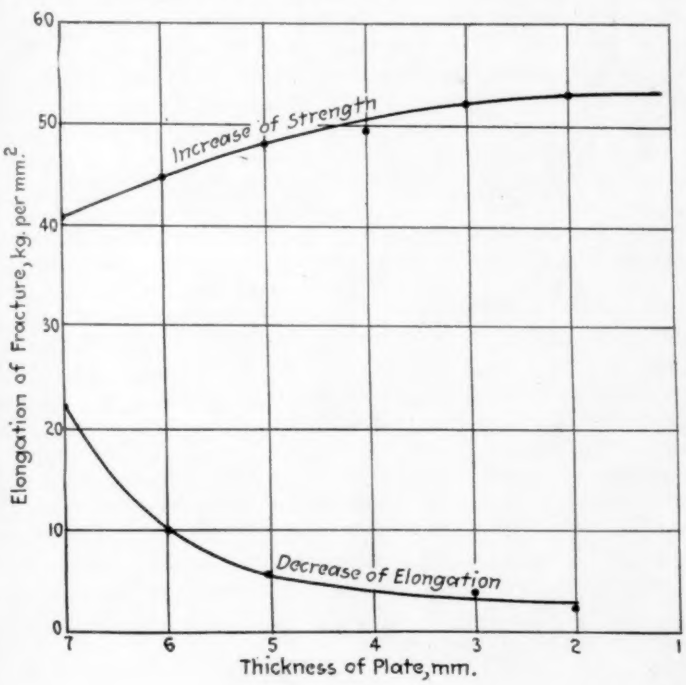


Fig. 1

Fig. 1 shows the increase in tensile strength and decrease in elongation of a duralumin plate as its thickness is reduced by cold rolling from 7 to 2 mm. The strength increases from 41 to about 54 kg. per sq. mm., while the elongation falls from 22.7 to 2.3 per cent. The curve

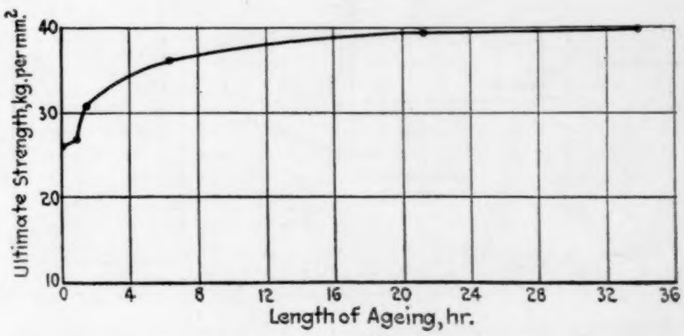


Fig. 2

shows that the elongation decreases very rapidly with the very first reduction in thickness. However, duralumin can be worked hot at a temperature of about 400 deg. cent. (752 deg. fahr.) very well.

Duralumin can be tempered, like steel, by heating and suddenly cooling. For this purpose plates, tubes, and shapes are heated to between 480 and 510 deg. cent. (896 and 950 deg. fahr.) and quenched, then aged; that is, the treated material is simply set aside. The original strength characteristics are very nearly restored after the quenching but the tensile strength continues to grow with the time of ageing, from 35 to 50 kg. per sq.mm. The elongation does not decrease but remains at least the same and usually increases slightly. In practice the greatest strength is reached after about five days of ageing.

When heated to over 530 deg. cent. (986 deg. fahr.) duralumin becomes unusable. Consequently the treating is carried on in a bath of nitrates whose temperature can be carefully regulated and watched. During the ageing of the metal work cannot be done on it which would change the section, as in that case the strength will not increase further. After the completion of ageing, the material can be rerolled to obtain smooth surfaces. The strength is thereby increased at the expense of elongation.

Fig. 2 shows the increase of strength during ageing. The tensile strengths were determined by the Ericson test with 0.385 as a coefficient. This value was obtained from the experiments described below. Experiments have been made (See Fig. 3) by the Durener-Metallwerke to

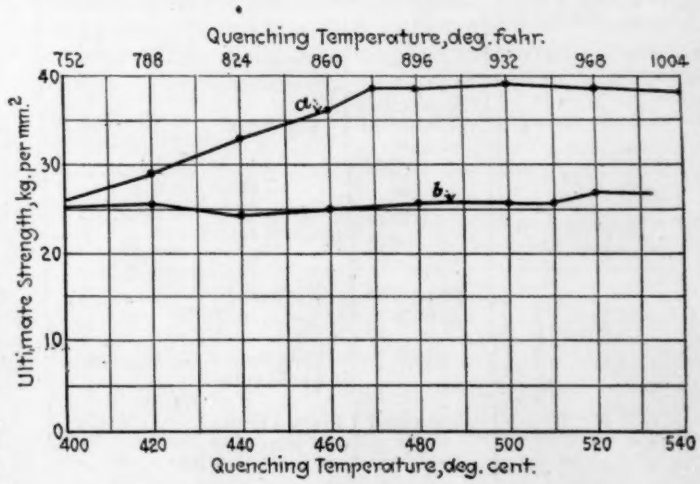


Fig. 3

[1]From a translation by Starr Truscott of an article appearing in the Technische Berichte, vol. III, sec. 6. The translation has been published by the National Advisory Committee for Aeronautics as one of its Technical Notes. Mr. Truscott who is a member of the Society is an aeronautic engineer in the Bureau of Construction and Repair, Navy Department, Washington.

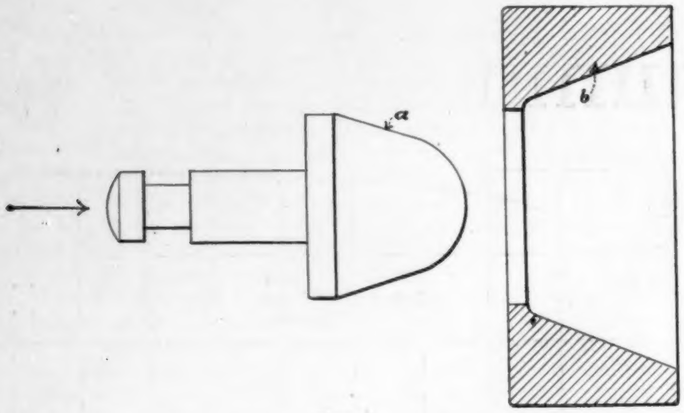


Fig. 4

determine the most favorable quenching temperature. The curve *a* shows the variation in the strength of duralumin which had been aged for four days with the variation of quenching temperature. Curve *b* shows the strength immediately after the quenching. The strengths were determined in both cases by the Ericson test. As the material may warp in tempering it is not good practice to temper riveted parts. Such parts should be tempered before they are riveted.

Strength Properties

Duralumin is delivered in various compositions which have different properties according to the purpose for which it is intended to be used. It is therefore important that the concern supplying the material should be informed regarding the nature of the working proposed. In Table 1 below are assembled the strength figures of some duralumin compositions made by the Durener-Metallwerke.

The modulus of elasticity of the hard composition 681a was found by the Technischen Hochschule Aachen to be 700,000 kg. per sq.cm. Making allowance for the possible effect of vibration on the modulus of elasticity it appears better to use not more than 650,000 kg. per sq.cm. in computations.

In judging as to the suitability of a material for use in stressed parts not only the tensile strength but also the ductility is of great importance. This can be determined by bending strips backward and forward through 180

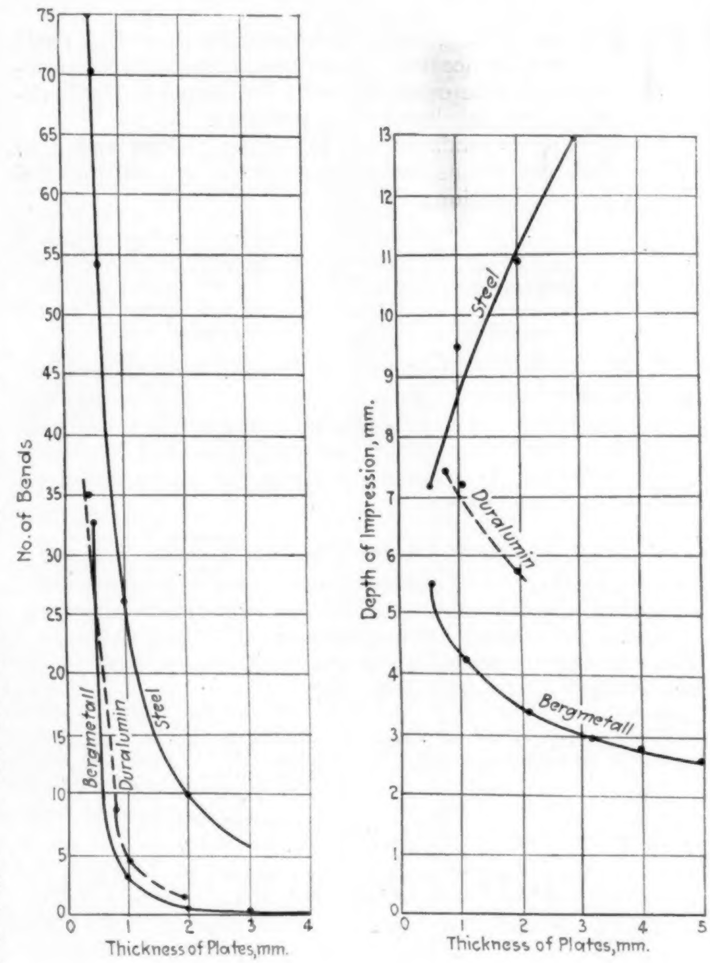


Fig. 5

Table 1—Strength Figures of Duralumin Compositions

Symbol for Composition	Condition	Method of Preparing	Elastic limit, kg. per sq. mm.	Tensile strength, kg. per sq. mm.	Elongation, per cent	Modulus of elasticity, kg. per sq. cm.	Sections available
681 b 1/3	Tempered only	Tempered	24 to 26	38 to 40	20	about 500,000	Tubes, plates, strips, bars and shapes.
	1/2 hard	Tempered and cold rolled	30	40 to 42	16 to 14	500,000	Tubes, plates, strips and bars.
681a	Tempered only	Tempered	25 to 27	38 to 40	20 to 18	600,000	Tubes, plates, strips, bars and shapes.
	Hard	Tempered and cold rolled	30 to 32	44 to 46	11 to 10		
681h	Tempered only	Tempered	26 to 28	38 to 42	18 to 15	600,000	
	Hard	Tempered and cold rolled	32 to 34	45 to 48	11 to 10		Tubes, plates, strips and bars
N	Tempered only	Forged rivets are tempered	20	32 to 34	18 to 14	Shear strength up to 6-mm. diameter 25 kg. per sq. mm.	Finished rivets.

Table 2—Comparison of Steel and Bergmetall

Thickness of Plate, mm.	STEEL Strength, kg. per sq. mm.	Elongation, per cent	No. of Bends	Depth of impression, mm.	BERGMETALL Strength, kg. per sq. mm.	Elongation, per cent	No. of Bends	Depth of impression, mm.
0.5	36	10.5	76	7.2	47	10.5	33	5.5
1.0	34	15.3	26	95.0	47	11.0	3	4.2
2.0	39	12.0	10	10.9	45	11.0	Fractured at 90 deg.	3.4
3.0	40	17.7	6	13.0	48	14.1	Fractured at 60 deg.	3.0
4.0					48	9.7	Fractured at 45 deg.	2.8

deg. over a definite radius, usually 5 to 10 mm., the number of bends before fracture being taken as a measure. Other conclusions as to the ductility can be obtained from the Ericson test (See Fig. 4). The plate to be tested is pressed through a ring, *b*, by a head, *a*, until a tear shows on the upper surface of the sheet. The depth of the impression is then a measure of the ductility.

In table 2 there are compared strength values, numbers of bends, over 5-mm. radius and through 180 deg. and depths of impression as observed on Bergmetall and steel plates of equal thicknesses. Although the strength values of the latter are less than those of the duralumin plates, nevertheless one can compare the figures as to number of bends and depths of impression without correction, since it is possible to obtain steel plate with a higher strength which also possesses great ductility.

The number of bends (See curves at the left of Fig. 5) for both metals decreases with increased thickness. For steel, however, they lie considerably higher than for duralumin. The difference is least for plates under 0.5 mm. in thickness. For thicker plates of duralumin the number of bends decreases very rapidly. A plate 2 mm. thick breaks over a 90-deg. bend; a plate 4 mm. thick over a 45-deg. bend. From these results duralumin might be referred to as "cold short" for thicknesses greater than 1 mm. This property makes it unsuitable for highly stressed parts which must at the same time withstand vibrations. This is of prime importance in connection with the bent lug plates which are ordinarily used in aircraft for taking wire terminals. In these lugs vibrations undoubtedly occur during flight which would reduce the strength of the duralumin and might cause sudden fracture. Exactly how vibrations influence the modulus of elasticity has not yet been determined, although experiments along this line are already under way.

A comparison of the depth of impression of steel and duralumin from the curves at the right of Fig. 5 shows that for steel the depth of impression increases with the thickness of the material, while for duralumin it decreases. As a result of a peculiarity of the testing machine used the greatest stress occurred at a point which was from 5 to 6 mm. from the vertex of the depression. In this locality the material began to flow before cracking. It is obvious that thick plates of ductile material may be stretched more easily on the upper surfaces and consequently deeper impressions obtained than with thin plates, since for thick plates more material can flow before fracture occurs.

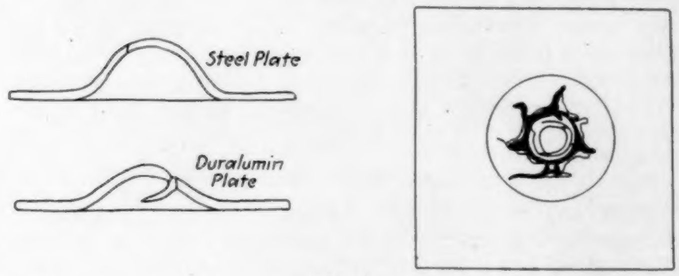


Fig. 6

A similar course of reasoning can be used to explain the decrease of the depth of the impression with an increasing thickness of plate in the case of material of less ductility. On the upper surface of the test-pieces there occur high tensile stresses at the point mentioned, which increase with the strength of the plate. As the material flows only to a small degree, cracks very soon appear and extend into the interior. The process described can be followed on the sections of a steel plate of about 40 kg. per sq. mm. strength and a duralumin plate, shown at the left of Fig. 6. The flow before fracture of the steel plate is plainly recognizable while the duralumin plate

Table 3—Influence of Cold on the Strength of Duralumin

Testing Temperature, deg. cent.	deg. fahr.	The Bar Was Tested in	Limit of Stretch and Strain	Tensile Tests Ultimate Strength, kg. per sq. mm.	Elongation, per cent	Impact Test, work of breaking, kg. per sq. mm.
+20	+68	Air	24.0	42.5	21.9	2.6
0	+32	Snow	23.6	43.0	21.8	2.6
−20	− 4	Mixture of snow and table salt	24.0	43.7	23.1	2.7
−40	−40	Mixture of snow and calcium chloride	24.0	44.0	22.1	2.7
−80	−112	CO_2 snow	25.2	44.4	22.7	2.7
−190	−310	Liquid air	32.3	53.7	28.7	2.6
+20	+68	Air	23.0	42.3	23.3	2.6

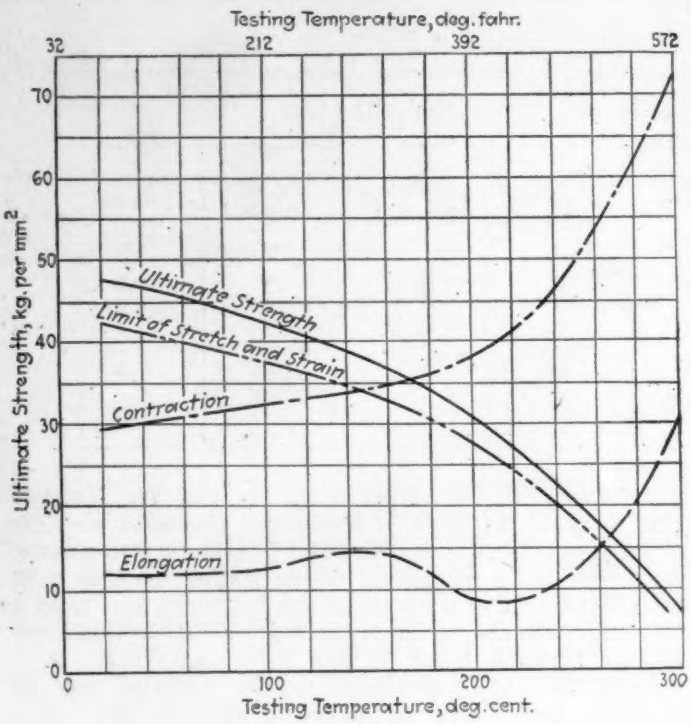


FIG. 7

shows hardly a sign of it. The right half of this illustration shows the appearance of a test sample of strong duralumin plate after fracture in which the material suddenly split in all directions. For flanging and pressing tempered duralumin is consequently suitable only in the thin gages.

Influence of Heat and Cold

Heat has an important influence on the strength of duralumin. According to the results obtained in tests by the Central Bureau for Scientific Investigation, Neubabelsberg, when heated the strength decreases 10 per cent for an increase in temperature of 100 deg. cent. (212 deg. fahr.) and about 20 per cent for an increase of 150 deg. cent. (302 deg. fahr.) (See Fig. 7.) The loss in strength increases with the increase of temperature. The elongation increases on first heating to a hardly appreciable extent, while between 150 and 200 deg. cent. (302 and 392 deg. fahr.) it decreases. At 250 deg. cent. (482 deg. fahr.) the elongation becomes the same as at room temperature. With further heating the elongation increases with a rising temperature. Consequently wherever duralumin is exposed to heat the possible decrease of strength must always be considered.

As opposed to this the influence of cooling on the strength properties is less unfavorable. The Central Bureau for Scientific Investigation has made tests on this also (See Table 3). The strength and elongation increase somewhat with the decrease in temperature. The work represented by the blow in the impact tests is not decreased when material is affected by cold so that one can safely assume that the cold encountered in flight has no unfavorable influence on duralumin.

Experiments on the influence of weathering on the strength of duralumin, which have been carried on by the Durener-Metallwerke for three years, have shown that no observable decrease in the strength properties can be noticed (See Table 4).

The Durener-Metallwerke has also carried on for about a year experiments on the influence of the electrolytic effect from junctions of duralumin with iron or steel. These were made by riveting duralumin bars to iron plates and then placing them in artificial sea water. There resulted only an insignificant destruction of the iron and a reduction in weight of the bars of about 0.23 per cent so that no considerations exist against the use of duralumin and iron junctions in aircraft.

Conclusions

Duralumin has a strength of 35 to 40 kg. per sq. mm. and an elongation of 10 to 15 per cent. The stretching strain limit lies very high, about 28 to 32 kg. per sq. meter. The modulus of elasticity is about 600,000 to 700,000 kg. per sq. cm. It is very brittle especially in thicknesses above 1 mm. and consequently sensitive to alternate bending to and fro.

Bent plate fittings, with bent lugs which must resist vibration, are best not made out of duralumin but of sheet steel. For stressed parts which while in flight are exposed to an increase in temperature of more than 100 deg. cent. (212 deg. fahr.) the use of duralumin is objectionable unless a correspondingly smaller strength value is used in computations. Cold has no harmful influence on duralumin. The joint between iron and steel and duralumin can be made without electrolytic action occurring. Pieces, which for better working must be heated, must be in all cases retempered after completion.

MACHINE-GUN TARGET BALLOON

THE balloon construction class of the vocational school at Lee Hall, Va., has completed the T-1, a target balloon designed by Lieut. Lober. This balloon is an elongated sphere having a vertical axis of 18 ft. and a maximum horizontal diameter of 12 ft. A cloth target is to be suspended below the balloon, which will be used as either a stationary or a movable target for the purpose of giving machine gunners aerial target practice. It will be towed by a motor vehicle.—Air Service News Letter.

TABLE 4—EFFECT OF WEATHERING ON THE STRENGTH OF DURALUMIN

Testing Data Alloy 681a	Dec. 1909		Nov. 1910		Nov. 1911		Dec. 1912	
	Strength, kg. per sq. mm.	Elongation, per cent	Strength, kg. per sq. mm.	Elongation, per cent	Strength, kg. per sq. mm.	Elongation, per cent	Strength, kg. per sq. mm.	Elongation per cent
Round Bar	41.7	20.0	42.2	21.0	42.0	21.1	42.9	18.3
Bar (thick)	39.1	20.0	38.7	19.6	39.3	18.9	40.0	20.0
Bar (thin)	42.0	20.0	39.1	18.0	39.3	18.0	42.3	16.5
Wire (thick)	48.0	20.1	45.0	20.1	44.3	19.7	44.5	19.8
Wire (thin)	46.3	20.0	44.0	19.6	42.5	18.7	43.2	18.5

Why Use Pneumatic Tires for Motor Trucks?

By W. E. Shively[1]

Cleveland-Detroit Sections Paper

EVERY development in the transportation industry has been toward a faster, more reliable or cheaper method of transporting men and materials. No one will deny that the motor truck is a very significant development in the transportation system of the world. This was conclusively proved in the world war. I believe most of us are of the opinion that the motor truck is destined to become the most important factor of our transportation system; but, judging by the events of the past two years, I believe that automotive engineers will not disagree with me when I say that the development of the motor truck has been limited by the solid tire. cushioning effect

At first, solid tires were used on all but light delivery trucks. On every other type of highway motor vehicle, the limitations of the solid tire were soon discovered and the solid tire was replaced by the pneumatic tire. But the tire manufacturers had not kept pace with the development of the motor truck, inasmuch as they had not perfected a large enough pneumatic tire. Tire engineers, however, were among the first to recognize the shortcomings, and proceeded to develop a large single pneumatic tire for motor-truck use. That they have succeeded is proved by the many thousands of these tires which have given satisfactory service in all parts of this country and with our army in France.

Any discussion of the relative merits of pneumatic and solid tires must of necessity reduce itself to a comparison of the elasticity of compressed air with that of rubber. We are accustomed to think of rubber as a very elastic substance, but it cannot be compared to compressed air in this respect. In one instance we ride on rubber, in the other on air. Very little imagination is necessary to realize what would happen to a modern passenger car if it were equipped with solid tires and run under conditions similar to those under which passenger cars are operated. The reasons that motor trucks can be operated with any degree of success on solid tires are that they are operated at relatively low speeds and are built so heavy that they will endure the shocks and vibration to which they are subjected.

If it is possible to use pneumatic tires on passenger cars to such advantage, it is reasonable to assume that certain advantages will result from their use on motor trucks, and the actual experience of many users has proved this to be true. It has been found that two fundamental advantages result from their use on trucks, increased cushioning and increased traction. The increased cushioning is the most important factor, because it has a greater effect on the performance of the truck. The cushioning ability of a pneumatic tire is four times as great as that of a solid tire of the same carrying capacity. As a result of this greatly increased cushioning, six distinct advantages are gained from the use of pneumatic truck tires

(1) Faster transportation
(2) Economy of operation
(3) Less depreciation of fragile load
(4) Easier riding
(5) Less depreciation of roads
(6) Lighter weight trucks

Each of these six points will now be discussed separately and, wherever possible, actual data will be presented to substantiate the claims made. These figures have been obtained from truck operators, each of whom has taken two trucks of the same make and capacity, one equipped with pneumatic tires, the other with solid tires, and operated them under exactly similar conditions; that is, over the same roads and carrying the same loads.

Transportation and Operation Economies

Faster transportation or quicker deliveries result from the increased cushioning of pneumatic truck tires. Operators have found this to be true because it is possible to obtain greater maximum and minimum speeds. Manufacturers of solid-tired trucks remove their guarantee if a speed of 11 or 12 m.p.h. is exceeded, while pneumatic-tired trucks are being operated at 20 to 35 m.p.h. But in ordinary city or farm hauling we are more interested in a greater minimum than in a greater maximum speed. That is, in running over rough city streets or country roads, a solid-tired truck must operate at slow speeds, because of the shock and vibration. It is therefore evident that if a truck on pneumatic tires will make more or longer deliveries in a given number of hours, its radius of operation is increased and also its earning power. Table I shows the increased mileage obtained with pneumatic tires by four truck operators.

Table I

Details	Operators[2]			
	A	B	C	D
Truck capacity, tons	2	3½	2	2
Period, months	6	1	5	4
Mileage on pneumatic tires	6,414	1,995	5,510	7,014
Mileage on solid tires	4,476	675	2,223	4,677
Miles per gallon of gasoline on pneumatic tires	5.77	5.75	7.21	7.70
Miles per gallon of gasoline on solid tires	3.98	4.77	5.43	7.10
Miles per gallon of oil on pneumatic tires	104.00	32.00	55.00	152.00
Miles per gallon of oil on solid tires	59.00	30.70	54.00	78.00
Cost per mile on pneumatic tires, cents	45.00	31.30	21.50	27.70
Cost per mile on solid tires, cents	56.30	55.00	24.00	31.00

[2]With a 2-ton truck for a 9-month period, a fifth operator obtained 9.1 miles per gal. of gasoline on pneumatic and 6.1 miles per gal. on solid tires.

[1]J.S.A.E.—Development engineer, Goodyear Tire & Rubber Co., Akron, Ohio.

The economy of operating trucks on pneumatic tires has been shown by the experience of many users. There is a considerable saving in gasoline, oil and upkeep. Furthermore, depreciation charges can be reduced considerably. The saving in gasoline is due to a lower power consumption resulting from the increased cushioning obtained. It is a well-known fact that vibration in a machine of any kind results in a loss of power. The vibration caused by the solid tires is practically eliminated by the use of pneumatic tires. I made a statement to the effect that a pneumatic tire possesses four times the cushioning ability of a solid tire. In rolling over an obstruction in the road, a solid tire lifts the entire load on the tire four times as high as it would be lifted in the case of a pneumatic tire. Many roads are full of small obstructions and a certain amount of power is lost in lifting the load of the truck over them. The relative cushioning ability of the two types of tire seems to indicate that the power loss from this cause is four times as much for solid as for the pneumatic type. There is also a saving in power in climbing hills. Because it is possible on pneumatic tires to approach a grade at a much higher rate of speed, less power will be consumed in climbing the grade; it will not be necessary to shift gears as soon, and possibly not at all. The saving in gasoline in the case of five truck operators is shown in Table I; also the saving in oil consumption. The statistics from four truck operators show a considerable saving in oil consumption, probably due to the decreased vibration in all of the moving parts of the truck.

The upkeep or repair cost of a truck operated on pneumatic is much less than when operated on solid tires. The experience of a large number of truck operators has shown this to be true. It can be attributed to the decreased amount of vibration and the absence of severe shocks and jolts. It is found that parts do not need to be replaced, and that the truck does not need to be overhauled as often. Information pertaining to the upkeep cost of the trucks from which we have taken the other data in this paper cannot be considered reliable, inasmuch as the records do not cover a sufficient period. Reliable information cannot be obtained in less than one year. The estimated saving in upkeep cost is from 25 to 50 per cent. Regarding depreciation charges, as a result of experience, Goodyear solid-tired trucks are depreciated on the basis of 60,000 miles of service, while the pneumatic-tired trucks are depreciated on a basis of 80,000 miles. In my opinion the 80,000 miles is too low, because there have been Goodyear trucks on pneumatic tires which at the end of 250,000 miles were still in good running condition. I believe that in the near future trucks will be depreciated on the basis of 100,000 miles. Taking all of these cost factors into consideration, it is found that the cost per mile of operating trucks on pneumatic tires is considerably less than that on solid tires. Referring again to the data obtained from truck operators who have kept accurate records, this claim is substantiated as shown in Table I.

Depreciation of Loads and Roads

Let us consider the lessened depreciation of fragile loads resulting from the increased cushioning ability of pneumatic tires. This is now considered by many users of these tires to be one of the most important advantages. While actual data cannot be submitted to substantiate this point, many truck operators engaged in different classes of service have found this to be true. For instance, in hauling fragile materials such as bottled goods and eggs, there is very little, if any, breakage. The farmer experiences very little depreciation in the live stock and produce which he hauls to the markets. Manufacturers have found that many of their products could be shipped without being cased. Then there is the easier riding made possible by the use of pneumatic tires. In the case of delivery trucks, the elimination of the vibration makes it possible for the truck driver and his helper to ride almost continually without fatigue. This is of vital importance in long-distance hauling, where it is necessary to drive for hours at a time. Easy riding is absolutely essential in passenger buses, from the standpoint of both comfort and speed. If the buses do not ride comfortably, the public will not patronize them, and of course speed is very desirable in passenger service.

The question of good roads is now a very important one. Before the motor truck can be utilized to the full extent of its possibilities, good roads are essential. However, along with the legislation providing these, laws are being considered and in some instances passed, restricting motor-truck traffic. A pneumatic-tired truck has very little more harmful effect on an improved road than a passenger car. This is not true of a solid-tired truck. The effect on dirt roads is the most harmful. Attempts have even been made to prohibit solid-tired trucks from using certain roads, and on some of the principal thoroughfares of our cities this has already been done. Because of the almost total absence of vibration and severe shocks on pneumatic tires, it will be possible to make many of the parts of the truck lighter in weight, thereby decreasing the initial cost of the truck and increasing the pay load, which means again, greater earning power.

Increased traction is made possible by the greater width of the pneumatic tires, their non-skid treads and their greater flexibility, which allow the surface of the tire to conform more nearly to the unevenness of the road, thereby getting a better grip. As a result of this increased traction, we obtain reliability and safety. By reliability we mean that it is possible for the truck to operate successfully over almost any kind or condition of road, and during all seasons of the year. Truck operators have found that they can use their pneumatic-tired trucks in many ways in which a solid-tired truck could not be used and, instead of laying them up during the winter, could use them continually without becoming stalled in mud or snow. By safety is meant that, because of the increased traction of the tires, the truck will hold the road better and the brakes will be more effective. This point has been thoroughly proved by the experience of many users of pneumatic truck tires and the Goodyear Akron-Boston trucks. In traveling over the mountains along the Lincoln highway during the winter, this increased traction has saved both drivers and trucks from serious accidents, on numerous occasions.

Cost

All arguments against the use of pneumatic tires on trucks can be placed under the head of either cost or practicability. It is found that the cost is subdivided into initial cost and the possible loss due to injury and abuse. While it is true that the initial cost of truck pneumatic-tire equipment is greater than that of solid-tire equipment, it has been proved by the experience of many truck operators that this difference is more than offset by the greater earning power and the lower cost of operation. It has usually been found that in from 4 to 6 months the increased cost of the pneumatic-tire equipment is completely wiped out. When specially designed pneumatic-tire trucks make their appearance, this increased cost of pneumatic-tire equipment will be offset

by the lower initial cost of the truck itself. There are, of course, many instances where the question of tire cost is secondary to that of speed or easy riding.

As to possible loss due to injury or abuse of the tires, it has been found that this is not a serious objection. There are many instances where pneumatic truck tires have run from 12,000 to 20,000 miles on the original air. As the development of the tires themselves has progressed, so has the successful repairing of the tires been worked out. Repair molds and retreading equipment are now in use in many parts of the country, and are being placed in other localities as rapidly as possible; so, it will be no more difficult to have a pneumatic truck tire repaired than any other part of the truck. While it is possible to injure pneumatic truck tires by abuse, this is no more likely to happen to the tires than to other parts. However, it is possible to repair most of the injuries to tires from abuse. As truck operators become more accustomed to the use of pneumatic tires, failures from abuse will be few.

Practicability of Pneumatic Tires

The practicability of pneumatic truck tires has been questioned probably more than anything else. The first thing to be discussed under this subject is that of delays due to changing tires. The amount of time necessary to change a tire depends upon the type of rim equipment. In the case of detachable rims, where it is necessary to remove the tire from the rim, replace it and then inflate it, it does not require more than 30 min. to perform the entire operation. In the case of a demountable rim, a change can easily be made in 15 min. I am not trying to argue the relative merits of the two types of rim, but an occasional delay of from 15 to 30 min. is not to be considered when hours will be saved every day that the truck is in operation if it is equipped with pneumatic tires. The average truck driver is not required to make a tire change more than once in three months.

It is often said that it is not possible to maintain the high inflation pressures required for pneumatic truck tires. Very little difficulty has been experienced in this respect. Most garages and service stations now carry sufficient air pressure to inflate tires up to the 42 x 9-in. size, and many can take care of the larger sizes. By the time the largest tires are in general use, there will be sufficient air pressure to keep the tires properly inflated. Trucks equipped with detachable rims, or operating in long-distance or inter-city service, are usually equipped with small air compressors. These trucks experience no difficulty in securing sufficient pressure. One objection, which is not mentioned so much now as when pneumatic truck tires first made their appearance, is the danger of the high inflation pressures carried in these tires. Pneumatic truck tires are made to withstand three to four times the pressure carried in them, so that this objection must be passed to the rims. This is also true of the rim; it is made to withstand many times the pressure carried in the tires. If the rim is properly assembled, there is small chance of accident. While it is true that a few accidents have occurred from this cause, they are usually the result of carelessness. Regarding the rise in pressure caused by the heating up of the tire, we have operated these large tires under the most severe conditions possible and in no case have we found an increase in pressure of more than 35 lb. per sq. in. If the tires are made to withstand three to four times the pressure at which they are operated, it is hardly possible that this additional 35-lb. pressure will cause them to blow out.

The large outside diameters of the tires are often objected to because they affect the truck ability and because they raise the center of gravity of the truck. In changing over a solid-tired truck to pneumatic tires, there is the possibility of reducing the ability of the truck. Our experience has shown that unless the truck is operated over a very hilly route, its ability has not been noticeably affected. There have been too many successful change-overs to allow this to become a serious objection. Looking into the future, this question of truck ability and gear ratios will be taken care of by changes in design; so, the question of change-overs is only temporary. Raising the center of gravity of the truck is not as serious as it might seem. The question of getting the load into the truck has not been serious. I believe that the loading platforms are not of such a uniform height that a slight change in the height of the truck platform would make a great difference. This question also appears only temporary. It seems possible to adjust this height in redesigning the truck.

It has been said that in case a large rear tire suddenly becomes flat the sudden drop of the truck might turn it over on a crowned road. When a large tire goes flat, it does not do so suddenly. The blowout or cut in the tire is never very large; so it takes some time for the air to escape and the truck does not tip suddenly. Furthermore, when all of the air is out of the largest tire now made, a 48 x 12-in., there will be a drop of only 5 in. Assuming that the track of the rear wheels is 66 in., the list of the truck would be approximately 4½ deg., which is not enough to cause the truck to turn over.

[The discussion of this paper is printed on page 377.]

THE FIRST ARTILLERY FIRE ADJUSTMENT BY AIRPLANE

In 1911 while Lieut.-Col. John Ruckman was in command of the coast defenses of Manila Bay, the question of firing at land targets on the heavily wooded mainland and on the distant beaches came up. Lieut.-Col. Ruckman, who was ultra progressive in all matters pertaining to artillery fire control, suggested the use of a camera from an airplane to locate the target and catch the bursts. About this time the Signal Corps was starting a small flying school at Manila. In 1912, Lieut. H. A. Dargue volunteered to take flying lessons, and in due season brought a Wright hydroplane to Corregidor Island, where he established a hangar and made frequent flights. He quickly demonstrated the futility of trying to hide submarine mine fields, often bringing in very accurate reports of the number and exact location of the mines.

When the plane arrived, operations were under way to fire at certain earthworks erected on a tall hill in the forests near Marivales Mountain. Lieut. Dargue had acquired some skill in using an ordinary camera in a seaplane. He would drop his controls, quickly point and snap the camera and then resume the controls. He made many interesting pictures of the neighborhood. In 1912 and 1913, he reported on the shots fired at Marivales redoubt and at the shore targets. Two photographs of what were probably the first artillery reglages by airplane were taken by Lieut. Dargue. Many of the photographs taken were of a highly confidential nature. They had great bearing on the principles of camouflage, which art was in use there at the time. These photographs bore out the theories of Lieut.-Col. Ruckman on the detection of targets by aerial photography.—Air Service News Letter.

Data on Pneumatic Tires and Rims Used on Trucks

By Burgess Darrow[1]

Cleveland-Detroit Sections Paper — *Illustrated with* Drawings

THE object of this paper is to familiarize truck engineers, and others interested in truck design, with facts and opinions which will assist in providing correct pneumatic tire and rim equipment for trucks. The sizes which have been worked out during the past six years, and which are now standard, are as given in Table I.

Table I.—Sizes of Pneumatic Tires

Rim Sizes, in.	Normal Tire, in.[2]	Oversize Tire, in.[3]	Extreme Maximum Allowable Load per Tire (Cord), lb.	Inflation Pressure, lb. per sq. in.
34x5	34x5	36x6	1,700	80
36x6	36x6	38x7	2,200	90
38x7	38x7	40x8	3,000	100
40x8	40x8	42x9	4,000	110
40x8	42x9	....	5,000	120
44x10	44x10	....	6,000	130
48x12[4]	48x12	....	8,500	140

[2]Original equipment on new trucks.
[3]Not for original equipment; only for consumer's convenience.
[4]Not yet standard with S. A. E. practice.

The 34 x 5-in. tire is a new size this year. It is not yet standardized, but it is the connecting link between the smaller sizes, commonly called passenger-car sizes, and the larger. It gives us a group of sizes ranging from 5 to 12 in. and, by selecting the overall diameters that we have, each one fits a 24-in. diameter wheel. The point of having all tires with a 24-in. wheel diameter is that we have the minimum number of tires; that is, one only of each cross-section diameter. Therefore, given any rim, there is a regular tire for the rim. If unusual conditions come up in the field demanding a larger tire, the next size larger tire, since they all fit 24-in. rims, can be used on the rim in question as an oversize to give extra carrying capacity or wear. Getting down to the minimum number of sizes by having one size only of each cross-section, is of benefit to the tire, truck and wheel manufacturers, to the truck and tire dealers and to the consumer.

Table I also gives the rim sizes, normal tire sizes and the tires which can be fitted as oversizes. It shows that there is no oversize possibility when 9, 10 and 12-in. sizes go out on new trucks, because the oversizing plan falls down above the 9-in. size, on account of the size and stiffness we are forced to build into the beads as designed at present. To explain oversizing further, this has been a possibility in the case of passenger-car tires since the beginning of the tire industry, and the originators of the plan showed good judgment in planning rim and tire sizes as they did. If oversizing has often proved a saving to the users of passenger cars, it is obvious that instances of the necessity of oversizing on trucks will be much more common. This is due to the greater range of loads the trucks will be called upon to carry, and the variety of uses to which the trucks will be assigned. Granting this, it is common sense for truck manufacturers to put out all trucks with suitable tires to carry the average load, and use normal size rims for the tires so that the consumer can oversize in cases demanding it. No new trucks should go out into service with the oversize combination of rim and tire already on them, thus depriving the user of his right to go one better in the way of tire size, if his conditions warrant it.

Concerning loads and inflations, I will only mention something about what pneumatic tires can stand in the way of flexing, to convey an understanding of the values of loads and inflations given in Table I. To the best of our knowledge tires give best average satisfaction in the way of plenty of cushioning and not too much flexing. Flexing breaks down a tire, when run under conditions which produce a deflection in the tire of from 12 to 15 per cent of the section diameter, or the height above the rim (see Fig. 1). The deflection can be controlled by regulating the load or the pressure, or both. Table I also gives the standard maximum loads and the inflation pressures. These inflation pressures are practical to maintain, the tires are built accordingly and we get satisfactory practical results in first cost and mileage delivered if they are used.

In reference to under-inflation and overload, both evils result in an excessive deflection of the tire. This means that an excessive shearing action is put on the rubber between the plies of the tire, and also on the cushion built into the tire between the tread and the plies, which in turn results in a separation of the parts and starts the tire on the road to failure. No careful truck driver would begin a day without attending to the water in radiator or the oil in the engine, because neglect of either one would damage the engine. Exactly the same daily

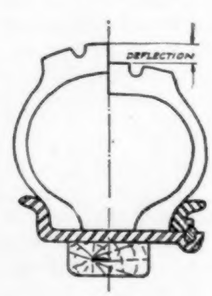


Fig. 1


Fig. 2


Fig. 3

[1]M. S. A. E.—Development department, Goodyear Tire & Rubber Co., Akron, Ohio.

attention must be given to tires in the way of inflation and an avoidance of overload.

The next thing is to show how the loads we recommend for the tires are adapted to the various sizes of trucks. The Tire and Rim Division of the Society investigated this, and its findings appear in the June, 1919, Report of Divisions of Standards Committee, page 24.[5] The weights of practically all makes of trucks were ascertained and plotted. It was found that all trucks of a given capacity weighed nearly the same when under full load, and it was possible to specify what the pneumatic-tire equipment should be on any truck of certain carrying capacity. The bodies on all the trucks in question were assumed to be standard stake bodies, and heavy bodies might in some cases necessitate a revision of the committee's findings. Table II is the original table, with a slight alteration in the tire equipment for front wheels on trucks of 1½-ton capacity and under.

TABLE II

Rim Sizes, in.	Normal Tire for Rim, in. (Original equipment on new trucks)	Oversize Tire for Rim, in. (Intended for convenience of consumer and not for original equipment)
34x 5	34x 5	36x6
36x 6	36x 6	38x7
38x 7	38x 7	40x8
40x 8	40x 8	42x9
[6]40x 8	42x 9	
[6]44x10	[6]44x10	
[6]48x12	[6]48x12	

[6]These sizes are not S. A. E. tire and rim sizes.

If any make of truck, fully loaded to its rated capacity, is checked up, it is surprising how close the weights on the tires come to the figures in Table II.

RIMS AND WHEELS

Leaving the subject of tires for the moment to discuss rims and wheels, there are now in satisfactory service wood wheels, cast steel wheels of eight or ten designs and disc wheels. On all of these can be mounted rims of either the so-called demountable type, a rim on which is carried an inflated tire, or the so-called detachable rim. The latter is perhaps a misnomer, because the rim is not detachable but the tire is removed by detaching a side ring from the rim, and spare tires cannot be carried inflated. (See Figs. 2 and 3.) The arguments for the demountable type are the inflated spare tire and the time required for a tire change. The arguments against it are the extra weight required, the extra cost and the possibility of mechanical troubles. The detachable-rim arguments are the exact opposite; in its favor are less weight and cost and greater freedom from mechanical troubles; against it are the time required for tire change and means of inflating the tire after it is changed.. Both types are practical. Table III gives an idea of the weights of the various tire, wheel and rim equipments. They are of neither the heaviest nor the lightest wheels, but represent what to expect as wheels are built today. This table enables one to calculate, approximately, various combinations of weights.

TUBES, FLAPS AND VALVES

Tubes for pneumatic truck tires must be designed and compounded so as to retain as much of their original

TABLE III.—WEIGHTS OF TIRE, WHEEL AND RIM EQUIPMENT

Tire Size, in. Front	Tire Size, in. Rear	Weight, lb.	Remarks
6	6	72	Weights of tires alone, without wheels or rims, but including tubes and flap.
7	7	87	
8	8	119	
9	9	174	
10	10	246	
12	12	398	
6	6	66	Weights of demountable rims complete with rim base, rim side rings, bolts and clips, but not wheel or felloe band.
7	7	75	
8	8	101	
10	10	132	
6	..	...	Weights of wood wheels, detachable rim type, including rim, rim side rings, and hub and, in the case of rear wheels, the brake drum.
..	6	...	
7	..	123	
..	7	166	
8	..	168	
..	8	223	
6	..	141	Weights of steel wheels, detachable rim type, including rim parts, hub and, in the case of rear wheels, the brake drum.
..	6	...	
7	..	130	
..	7	...	
8	..	...	
..	8	254	
..	10	235	
..	12	255	
6	..	116	Weights of wood wheels, demountable type, including felloe band, hub and, in the case of rear wheels, the brake drum, but rim parts other than the felloe band are not included.
..	6	...	
7	..	...	
..	7	169	
8	..	...	
..	8	170	

strength and shape as possible, after being subjected in service to more or less heat and to continued flexing. The tube has been one of the most difficult problems in connection with large tires, but has been solved partly in a mechanical way by building the tubes thick, shaped like the tire, and so they are stretched very little in the tire. The tube problem has been solved to a still greater extent by rubber compounding. Tubes are on a par with the casings in development and render satisfactory service even in the largest sizes. (See Fig. 4.)

Flaps assume considerable importance in tires inflated to the pressures we recommend for truck tires. It is important that the flap fit well, so that there will be no adjustment of the flap when the tire is inflated, causing a localized stretch in the tube at the edge of the flap.

The valve question had to be approached first from the standpoint of holding air at pressures from 90 to 140 lb. per sq. in. and, second, from the standpoint of ease of tire change. The valve insides on all 6-in. and larger tubes is of a heavy-duty type, different from the ordinary valve insides in construction, but the two are interchange-

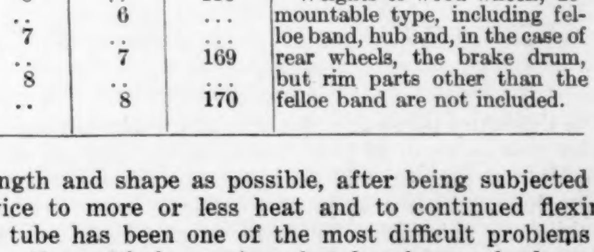


FIG. 4

[5]This report was submitted to the Standards Committee as general information only. It was not accepted by the Society for publication in the S. A. E. HANDBOOK.

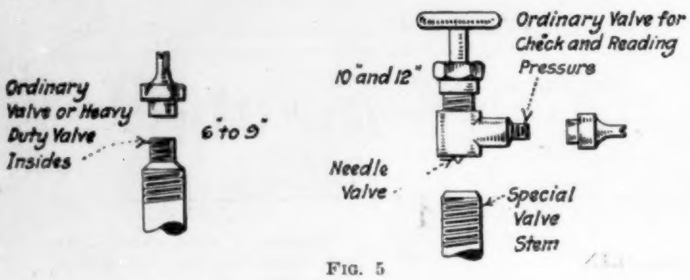


FIG. 5

able in any valve stem. On the 10 and 12-in. sizes, which inflate to 130 and 140 lb. per sq. in. respectively, even the heavy-duty type is unsatisfactory when used alone; so, a combination is used in the form of a heavy-duty valve insides and a needle-valve operated by a hand screw. (See Fig. 5.)

As to the relation of the valve to easy tire changing, it is customary in applying the small-size tires to insert the valve in the hole in the rim and tip the tire on the rim. This necessitates considerable clearance in diameter of the tire beads over the rim and, in 7-in. sizes and above, such design is impractical because the rims are wide and would necessitate too much clearance in bead diameter.

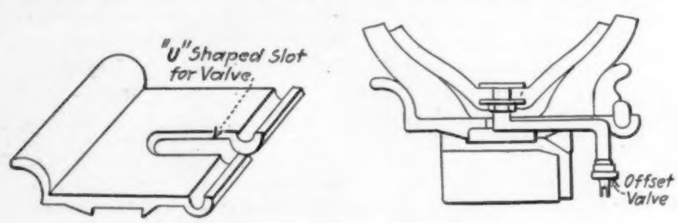
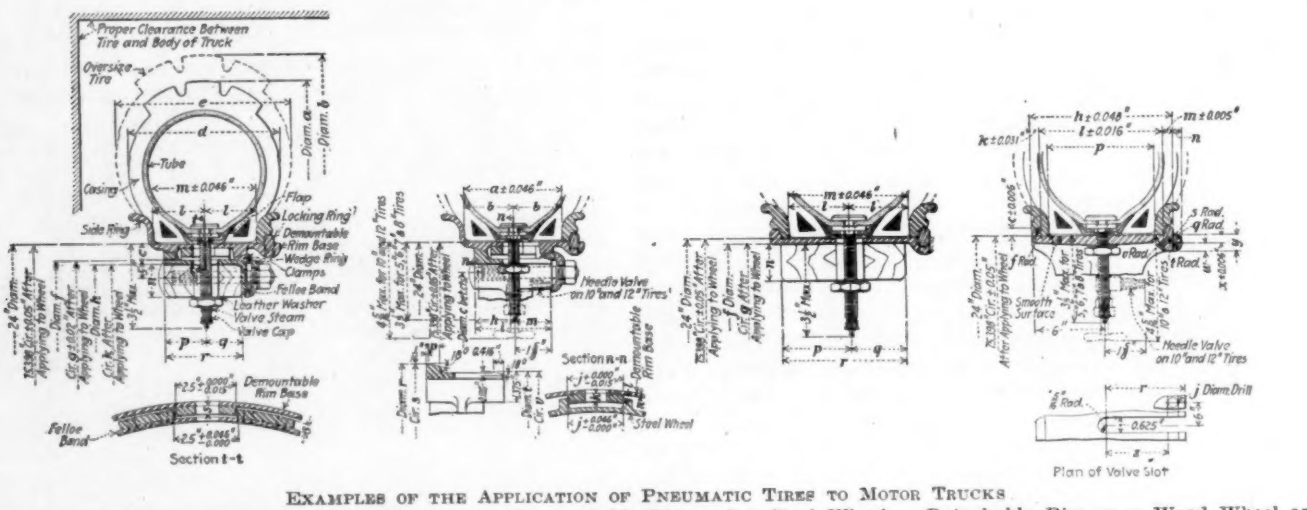


FIG. 6

It is therefore necessary if a straight valve and the usual valve hole is used, to push the valve up into the tire, fit the tire on the rim and then fish the valve through the valve hole, which sounds very difficult but is not. To avoid even this difficulty some steel wheels are made with a U-shaped slot from the edge to the center of the rim, which permits the tie to go on the rim with no difficulty at the valve. (See Fig. 6.) We have approved wheels slotted this way after having tested them, but believe an offset valve, a valve with two right-angle bends in it, will eventually be used. The offset valve requires only a depression in the rim from the edge to the center, and not a slot. The wheel is stronger than if slotted, and besides making application just as easy, the valve comes out at the edge of the rim and is more accessible to inflate.

DUAL PNEUMATIC TIRES

One more important item, the arrangement of tires on the trucks, presents three possibilities; the ordinary truck with giant tires on four wheels, dual pneumatics on the rear, and trucks with six or more wheels. We are primarily interested in carrying trucks on pneumatic tires; so, we have tried the three possibilities. As a result, we look unfavorably only on the dual pneumatics, that is, two tires on the same wheel. We tried the dual idea and abandoned it several years ago, but it crops up now and then and I want to state our reasons clearly for dropping it. Dual tires do not share the load equally because the inflation is seldom kept alike in both tires. Because of crowned roads, and more particularly rough roads, one tire takes more than its share of the load temporarily and this will injure the tire. An exaggeration of this condition is when one tire goes flat and the other tire takes all the load without the knowledge of the driver. The tire which still holds air is so badly overloaded that it is sure to be injured, if not ruined. Changing an inside tire, in the case of dual tires, necessitates removing both tires. One argument advanced for dual tires is that if one tire goes flat the truck can continue; but it cannot continue far. Another argument is that one size tire only need be carried for a spare, but this is unimportant. All these arguments can be summed up by saying that dual tires are too easily abused and prove more expensive than either of the other two possibilities. [The discussion of this paper is printed on page 377.]



EXAMPLES OF THE APPLICATION OF PNEUMATIC TIRES TO MOTOR TRUCKS
From Left to Right Are Shown a Demountable Rim, a Demountable Rim and a Steel Wheel, a Detachable Rim on a Wood Wheel and the Pneumatic Tire Applied to a Cast Steel Wheel

What Motor Trucks Need to Supplement Pneumatic-Tire Equipment

By E. W. Templin[1]

Cleveland-Detroit Sections Paper *Illustrated with* Drawings

WE realized some time ago that the introduction of the pneumatic tire for motor trucks would have a material bearing upon the design of the truck itself, to get the most good from the use of such a tire. For this reason, we have been making a study of the problem and have at this time certain considerations to present. The main factors bearing upon the problem of truck design for pneumatic tires are as follows:

(1) Speed, including road and engine speeds, rear-axle gear reduction and airbrakes
(2) Traction, including engine torque and transmission gear reductions
(3) Shock effects, including stresses introduced and the necessary factor of safety of sprung and unsprung parts
(4) Emergency equipment, including tire pumps and spare tires

Table I shows road speeds that we consider satisfactory, together with the usual rear-tire specifications for various sizes of trucks. The engine speeds are figured on the basis of 1200 ft. per min. piston speed, which is a figure we believe can be considered a good average. However, some engines on the market may not operate successfully at this speed and again others can stand a higher speed. Higher speeds set up considerable vibration and add discomfort to driving.

TABLE I.—ROAD SPEEDS

Present Solid Tire Gear Ratios	Average Governed Speed, m.p.h.	Capacity, tons	Pneumatic Tire Speed, m.p.h.	Tire Size, in.	Rear Wheel, r.p.m.	Drive, r.p.m.	Pneumatic-Tire Rear-Axle Gear Reductions
7 to 8	17	1 to 1½	30	36 to 38	280.0 to 265.4	1,450	5.18 to 4.47
9 to 10	15	2 to 2½	30	40 to 42	252.1 to 240.1	1,325	5.26 to 5.52
11 to 12	13	3½	25	38 to 44	221.1 to 191.0	1,200	5.43 to 6.28
12 to 13	10 to 12	5	25	40 to 48	210.1 to 175.0	1,200	5.72 to 6.86
14 to 16	9	7	20	42 to 44	160.1 to 152.8	1,200	7.50 to 7.85

Table II shows a study in computed speeds over a given course which corresponds somewhat to the course from Akron to Cleveland, going by the way of Tallmadge in the one case and by way of North Hill in the other. It will be noted here that a normal speed of 25 m.p.h. is required to double the average speed of a sold-tired truck whose normal or governed speed is 11 m.p.h. The answer of course is that the solid-tired truck has a higher tractive ability in high gear and hence is able to maintain its normal speed over many grades.

Fig. 1 on page 370 shows how time can be conserved by a careful study of gear reductions.

Brakes and Traction

On account of the comparatively high speed of the pneumatic tired trucks, it is necessary to equip them with brakes having 100 per cent more capacity than is

[1]M. S. A. E.—Motor-truck engineer, Goodyear Tire & Rubber Co., Akron, Ohio.

TABLE II

	Solid Tire, 1260 r.p.m.		New Job, 1400 r.p.m.		Six-Wheel, 1600 r.p.m.		K-1, 1400 r.p.m.	
	Speed, m.p.h.	Time, hr.	Speed, m.p.h.	Time, hr.	Speed, m.p.h.	Time, hr.	Speed, m.p.h.	Time, hr.
Tallmadge								
3 miles, 6 per cent grade	6.66	0.45	8.57	0.35	6.25	0.48	8.15	0.37
3 miles, 3 per cent grade	11.00	0.27	17.90	0.16	10.50	0.29	14.10	0.21
34 miles, level	11.00	3.09	25.00	1.36	25.00	1.36	23.00	1.48
Total time	.....	3.81	.....	1.87	.....	2.13	.....	2.06
Average speed	10.50	....	21.40	....	18.70	....	19.40	....
North Hill								
1 mile, 12 per cent grade	3.52	0.28	4.63	0.22	3.47	0.29	3.78	0.26
2 miles, 6 per cent grade	6.66	0.30	8.57	0.23	6.25	0.32	8.15	0.25
3 miles, 3 per cent grade	11.00	0.27	17.90	0.16	10.50	0.29	14.10	0.22
34 miles, level	11.00	3.09	25.00	1.36	25.00	1.36	23.00	1.48
Total time	.....	3.94	.....	1.97	.....	2.26	.....	2.21
Average speed	10.10	....	20.30	....	17.70	....	18.10	....

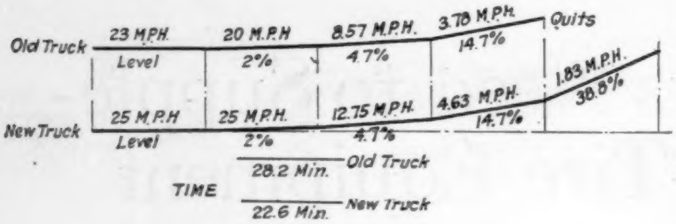


FIG. 1

the case with solid-tired trucks. This brings up the question of how to apply such a capacity easily. In answer to this, we suggest the application of brakes to the front wheels when all the capacity possible is attained in the rear. Front-wheel brakes are now well worked out, due to the use of trailers during the war which required brakes on the steering axles.

When the normal speed has been determined, we can next consider the tractive-ability required to get over the road without the inconvenience of shifting gears too often. The tractive factors that we consider desirable and satisfactory are shown in Table III, and are figured by the formula there given. The engine torque required to give these tractive factors is also shown, together with the sizes of engines on the market today that develop the torque required. There are conditions, however, where larger engines may be desirable and we believe smaller engines will not give satisfasctory speed.

shows a more compact gearset system that involves the combination of the two sets above referred to into one.

Shock Effect

Considering the allowable stresses, any fixing of allowable stress requires an investigation of the cushioning effect of pneumatic as compared with solid tires.

Fig. 5 on page 372 shows the rate of deflection of pneumatic tires and their corresponding solid tires, together with a curve showing how the solid tire depreciates in resilience with age and wear. It will be seen here that for a given load the pneumatic tire deflects four times as much as a solid tire. On this basis, Fig. 6 on page 373, will indicate that the stresses in unsprung parts due to shock build up to the same amount whether pneumatic or solid tires are used. There is, however, a difference in the time element; that is, the time required to build up the stress due to shock is, in the case of pneumatics, twice that of the solid tires. If any shading of the factor of safety is done, it seems that it is to be done on this basis.

As yet we have been unable to conceive of a method of testing or experimenting which will prove conclusively how much the factor of safety can be changed due to this time element. Any suggestions along this line will be appreciated. We have, however, taken 2-ton chassis, put in 3-ton truck engines and made the trucks haul 3½ tons of freight very successfully. From numerous trials like this we conclude that if a factor of safety of 6 is safe with solid-tire equipment, then 5 can be allowed for pneumatic equipment. This refers mainly to unsprung parts. In regard to sprung parts, it is rather problematical to even estimate the allowable stresses. It appears that the factor of safety can be shaded, but not so much as in the case of unsprung parts. For instance, with pneumatic, the frame is not jarred to pieces in the same manner as with solid tires and the rivets stay

TABLE III

Tractive Factor =
Maximum Engine Torque in pound-inches × Efficiency of Transmission (0.90 in high gear, 0.85 in other) × Gear Reduction ÷ Weight of truck and load in pounds × ½ the diameter of rear tire in inches

Truck Capacity, tons	Pneumatic Tire Tractive Factor	Corresponding Solid Tire Tractive Factor	Engine Torque, lb.-in.	Engine Sizes on Market that Develop Approximate Torque Required, in.		
1	0.07	0.085	1,650	3¾x5	4 x5	3¾x5⅛
1½	0.06	0.085	1,950	4 x5½	4⅛x5¼	4⅛x5½
2	0.06	0.083	2,500	4½x6	4½x6¼	4½x5½
2½	0.06	0.082	3,000	4¾x6	4½x6¼	
3½	0.05	0.077	3,000	4¾x6	4½x6¼	
5	0.04	0.070	3,200	5 x6	4¾x5½ (6 cyl.)	
7	0.04	0.060	3,300	5 x6	4¾x5½ (6 cyl.)	

When the high-gear tractive-ability and engine size have been determined, we have next the low-gear ability to consider. We find a tendency toward a low gear ratio in the transmission of 6 to 1 in 5-ton trucks. This in connection with present solid-tire axle-ratios gives a tractive factor of 0.42. A desirable low-gear ability for trucks equipped with pneumatic tires can be given as 0.50, although we feel that it should not be less than 0.30.

Table IV shows the low-gear transmission-ratios necessary to give these tractive factors. It will be observed that these ratios are considerably different from present practice and the question naturally arises as to how this can best be handled.

Fig. 2 shows a conventional design of transmission to give about 14 to 1 reduction in low gear. Superimposed upon this is a regular transmission of about 5 to 1 low-gear reduction, in general use today. From this it is evident that this construction cannot well be considered. The next best and easiest arrangement is as shown in Fig. 3, where we have a three-speed unit-transmission of regular design in combination with an auxiliary transmission having 3½ to 1 reduction. In combination with the 4 to 1 low-gear reduction in the unit set, we get 14 to 1 total transmission low-gear reduction. Fig. 4

TABLE IV

Truck Capacity, tons	Low Gear Tractive Factor	Engine Torque, lb.-in.	Total Gear Reduction	Rear Axle Reduction	Transmission Reduction in Low Gear	Trans. Redn. 0.30 Tractive Factor
1	0.50	1,650	49.1	5.18	9.47	5.68
1½	0.50	1,950	51.0	5.47	9.32	5.58
2	0.50	2,500	49.5	5.26	9.42	5.64
2½	0.50	3,000	51.7	5.52	9.37	5.62
3½	0.50	3,000	61.4	5.43	11.30	6.77
5	0.50	3,200	79.7	5.72	14.00	8.40
7	0.50	3,300	105.0	7.50	14.00	8.40

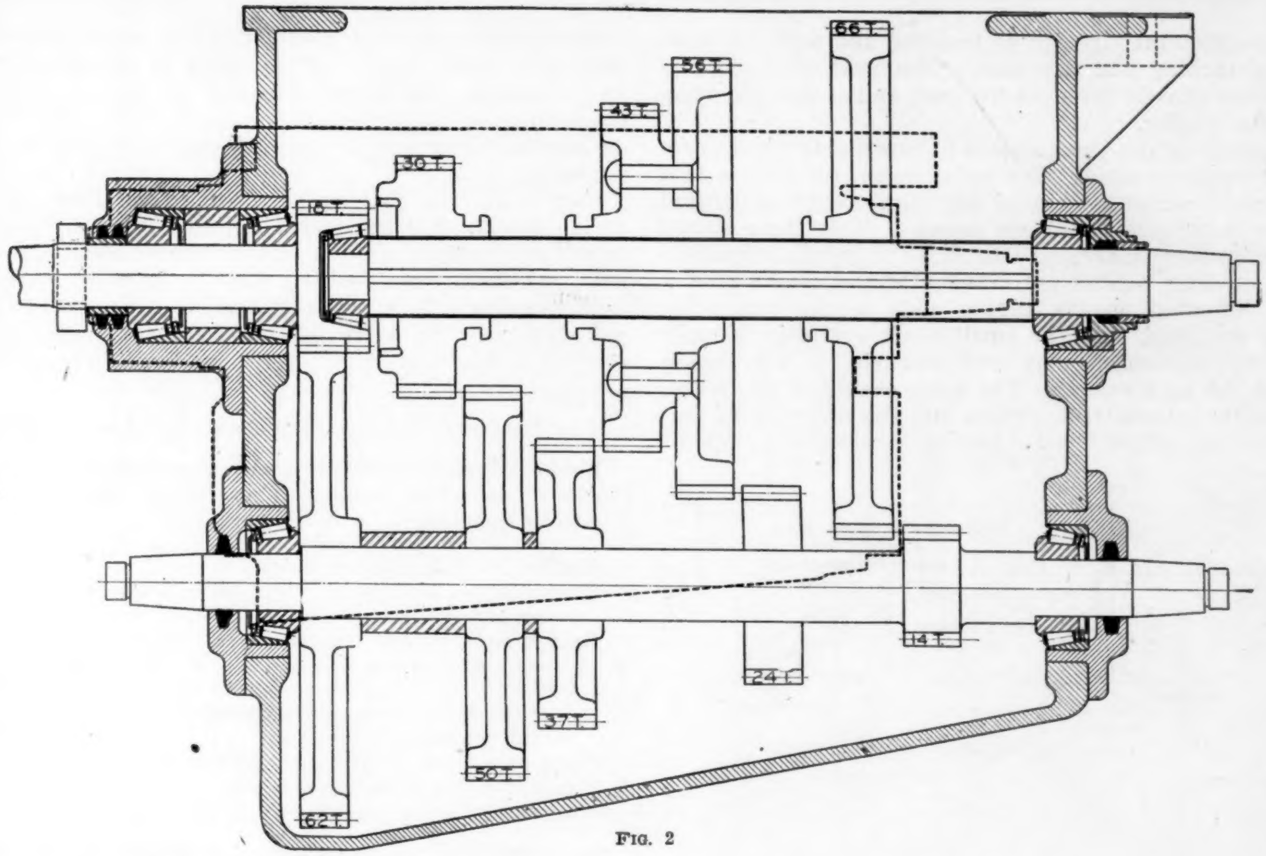


FIG. 2

tight. Fig. 7 on page 373 shows how the engine is cushioned by the pneumatic tire.

Emergency Equipment

Spare tires, one of each size, should be carried on the truck if it goes as much as 25 miles away from its base. The method of carrying spare tires is a difficult problem. However, I believe it is worth while to make "real" arrangements to handle this spare equipment by proper design of the body or chassis. Probably the best solution is to place a compartment directly back of the driver's

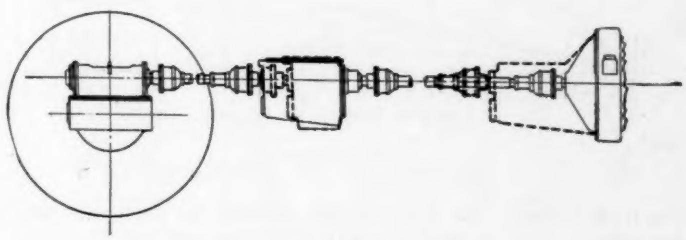


FIG. 3

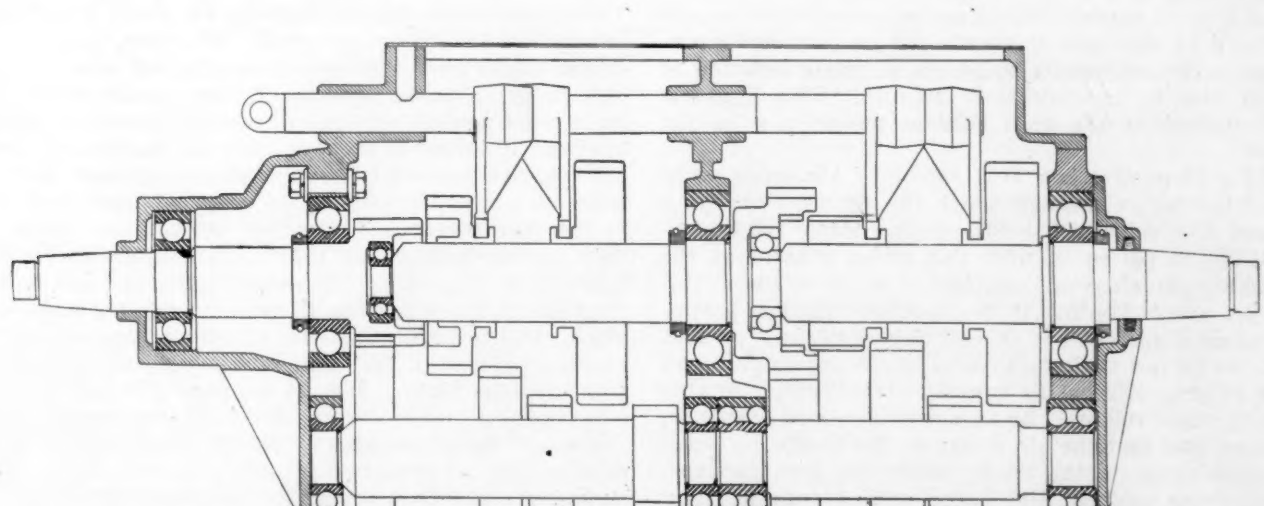


FIG. 4

seat, so that the tire can be removed and replaced without disturbing the pay load. The next best place is under the chassis frame at the rear, and at the side opposite the muffler.

A power-driven tire pump is indispensable when pneumatic tires are used. The main reason for this is that the truck cannot be moved any distance on a deflated tire without causing serious damage. This pump should be designed and arranged to drive from the transmission; at least this is preferable, for the reason that a pump mounted on the engine adds to the congestion under the hood, and the small shaft available, already carrying the water-pump and magneto, is not strong enough for an air-pump. The pump should be air-cooled, due to its intermittent service and the difficulty of embodying any efficient water-cooling arrangement without

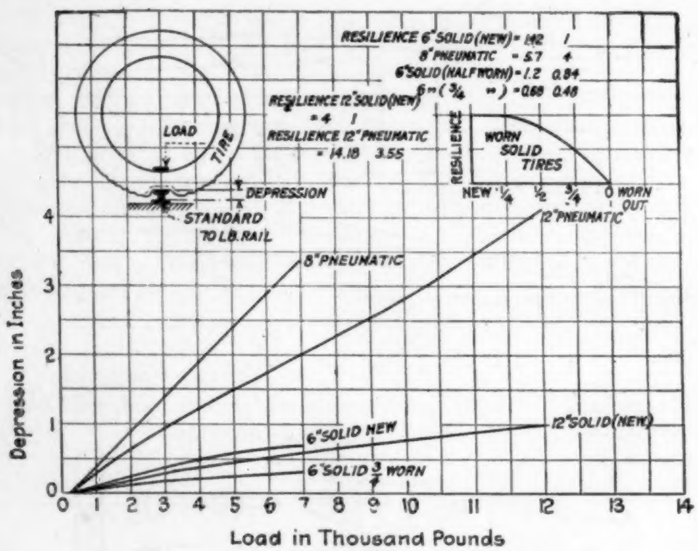


FIG. 5

much expense. Its lubrication should be well worked out with a view to avoiding any oil discharge which would injure the inner tube of the tire. The speed at which the pump is to operate should not exceed one-half engine speed and in any case it should not be over 600 r.p.m. The pump should operate to permit complete inflation of a 10-in. tire in approximately 10 min. This figure is being reached by the most efficient pumps now on the market.

A 44 x 10-in. tire has 5700 cu. in. of air space. The area of the orifice through which the air must pass in a standard tire valve is 0.00307 sq. in. Hence, if a pressure of 200 lb. per sq. in. upon this orifice is assumed, the very minimum time of inflation of a 44 x 10-in. tire would be about 6 min. It is debatable whether a two-stage pump is advisable in this service. Certainly, present design would not indicate this, as there are single-stage pumps fully as efficient as any two-stage pump, for this relatively small volume. As an aid to increased efficiency, it is suggested that the air intake on the pumps be piped to a clean point on the truck, under the seat, perhaps, thus insuring against dirt being sucked into working parts. At least 6 ft. of copper tubing should be placed between the pump and the hose, to avoid burning off the hose. The advisability of placing a small receiving chamber in the line, that would equalize the air pressure and assist in reducing the excessive temperature of the air delivered, has been suggested.

Pneumatic tires add considerably to the comfort of driving a motor truck. If the truck is to operate over long distances, additional attention should be given to the comfort of the driver, such as having an enclosed cab, an easy and comfortable steering gear and heat for the winter.

Cost is an item that strikes home to all of us. After giving this matter considerable study, I believe that it is possible to build a 5-ton motor-truck chassis equipped with pneumatic tires for only $200 to $300 more than a corresponding solid-tired truck, and that the net weight reduction may be easily 1000 lb. without resorting to aluminum where it is not yet considered commercially practical.

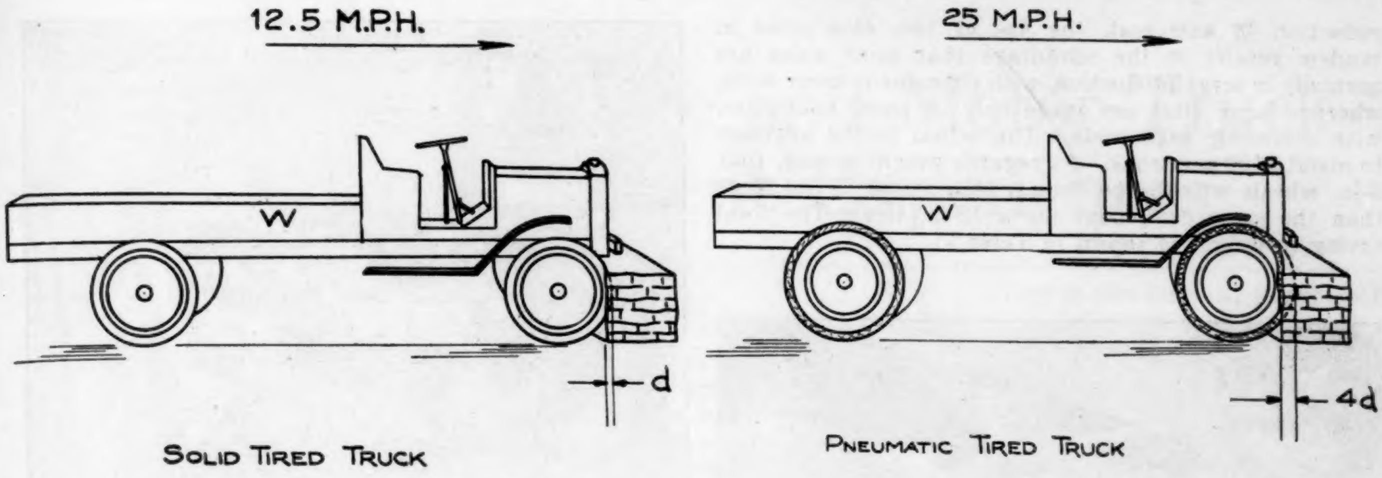
The New Six-Wheel Truck and Its Advantages

We have under construction at present two 5-ton motor trucks of six-wheel design. These trucks will have the following specifications:

Engine, 5 x 6 in.; four-cylinder
Transmission, unit power plant and auxiliary; 14 to 1 low-gear reduction
Rear axle, Goodyear tandem rear. Made up of two worm-drive axles, intended for use on 1½-ton solid-tire trucks in one case, and two internal-gear axles of the same rated size in the other. The rear-axle gear reduction is 5.8 to 1.
Front axle, intended for a 3½-ton solid-tire truck
Frame, 3 x 7 x ¼ in., pressed steel
Tires, 40 x 8-in. pneumatic; six in all

On account of the large size and weight of the 48 x 12-in. pneumatic tire, we were brought to consider the application of four smaller tires to the rear of the truck, instead of two of the excessively large ones. Our first attempt at an arrangement for applying four small tires to the rear without using dual tires, which is considered out of the question, is shown in Fig. 8 on page 374. It consisted of a more-or-less standard rear axle with a walking beam adapted to each end and the wheel mounted upon trunnions from this walking beam, the springs being mounted upon the axle and attached to the frame on the inside. Chain drive was made use of in this case, which is about the only feasible drive with this arrangement. This construction ran successfully for about 10,000 miles before serious failure occurred. We were, however, inconvenienced with the chains jumping off and were not able to get a brake mechanism that would work. The main point against this design was its enormous weight; however, it served to show us that satisfactory tire mileage could be secured from such an arrangement and that there was a good possibility of adapting four small tires to the rear wheels. To further develop this point, we built up the tandem axle construction as shown in Figs. 9 and 10 on page 374. This construction appears to have good possibilities and has at present operated some 3300 miles, 1000 to 1200 miles over rough and uneven country roads, so rough in fact that it was difficult to keep the front springs tight. Fig. 11 on page 374 indicates another very feasible design to adapt the tandem axles.

Some of the advantages of the six-wheel truck over the regular type of the same capacity, on 48 x 12-in. pneumatic tires and on the regular equipment of solid tires, are that compared with the pneumatic-tired four-wheel truck the saving by using four smaller tires is sufficient to purchase three or four complete spares, or approximately $500 per truck. Regarding ease of handling, each 40 x 8-in. tire weighs only 119 lb., whereas each 48 x 12-in. tire weighs 398 lb. Carrying a spare tire in each case, the



$$E = \frac{WV^2}{64.4}$$

$$E_s = \frac{20{,}000 \times 18.3 \times 18.3}{64.4}$$
$$= \frac{6{,}700{,}000}{64.4}$$
$$= 104{,}000 \text{ Ft.-Lb.}$$

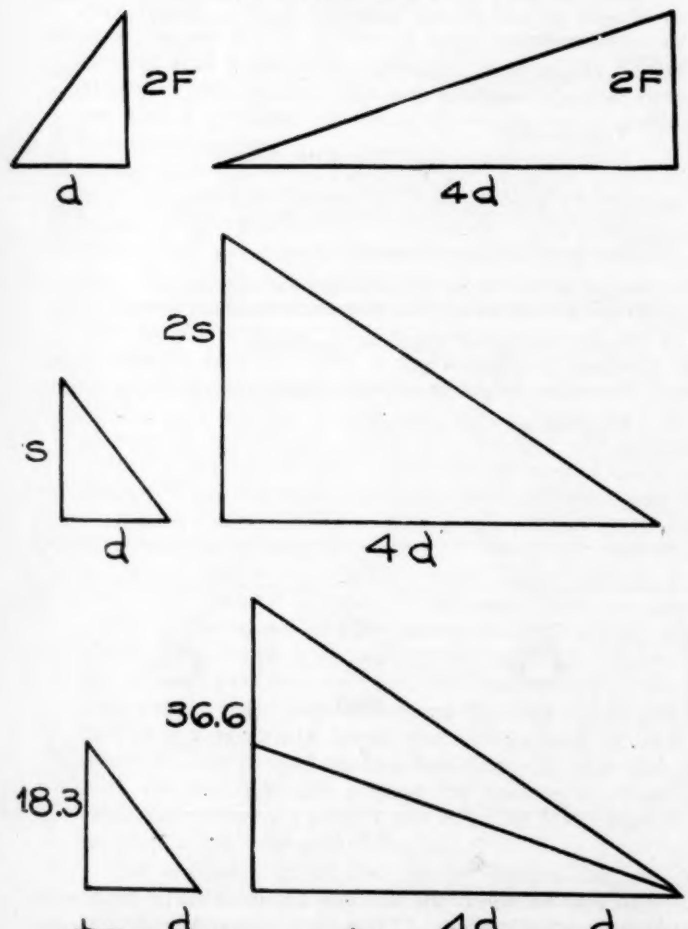
$$E_p = \frac{20{,}000 \times 36.6 \times 36.6}{64.4}$$
$$= \frac{26{,}800{,}000}{64.4}$$
$$= 419{,}000 \text{ Ft.-Lb.}$$

F_d = Work done in stopping truck
$= F_s = F_p$

$$F_s = \frac{104{,}000}{d}$$

$$F_p = \frac{419{,}000}{d}$$

$$\frac{104{,}000}{d} = \frac{419{,}000}{d}$$



$$t_s = \frac{d}{9.15} \qquad t_p = \frac{4d}{18.3} = \frac{d}{4.57}$$

$$t_s = \frac{1}{2}\, t_p$$

Fig. 6

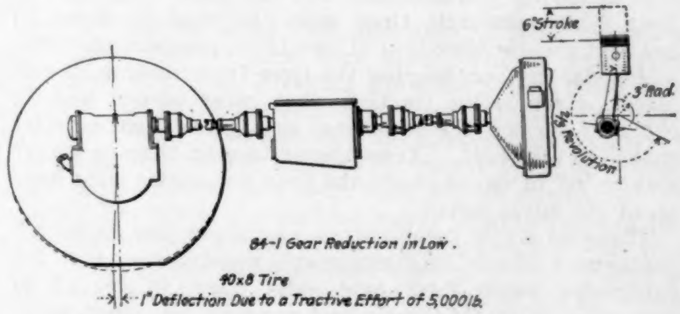


Fig. 7

$$n = \frac{t}{c}, \text{ and}$$

$$t = \frac{d}{s} \times g \times c, \text{ where}$$

n = Revolutions of engine due to circumferential deflection of tire
t = Travel of crankpin
c = Circumference of crankpin circle
d = Circumferential deflection of tire
s = Circumference of tire
g = Total gear reduction

$$t = \frac{1}{40 \times 3.1416} \times 84\ (6 \times 3.1416) = 12.61$$

$$n = \frac{12.61}{18.85} = 0.67$$

total weight reduction in tires alone amounts to 520 lb. in favor of the 8-in. tires. Then, again, the 8-in. spare can be used as a front wheel spare also, which still further reduces the tire investment. In reference to the

reduction in axle cost, the use of two rear axles in tandem results in the advantage that small axles are normally in large production, with consequent lower costs, whereas large sizes are made only in small quantities, with extremely high costs. The actual saving amounts to about $120 per truck. As regards weight saving, four 8-in. wheels with brake drums, etc., weigh 77 lb. more than the same equipment for a 12-in. tire. The total saving in weight is shown in Table V.

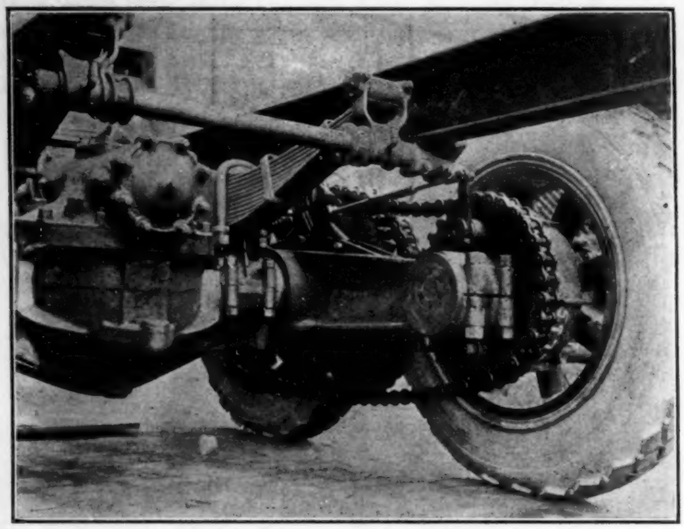


FIG. 8

Considering traction qualities, the area of contact of four 8-in. pneumatic tires upon the road is about 27 per cent greater than that of two 12-in. pneumatics. This additional surface, keeping the tires from sinking in soft places, gives better traction when most needed and, in ordinary service, the additional area gives them a better chance to take hold. As compared to solid tires in winter service, off of paved roads, the four pneumatic tires have all of the advantage.

The four-wheel combination has about the same advantageous effects over single-axle construction that the pneumatic would have over solid tires, in regard to economy. With the four-wheel combination, when passing over an obstruction in the road, the chassis is raised only one-half the distance it would be raised in the regular type of construction. This reduces the accelera-

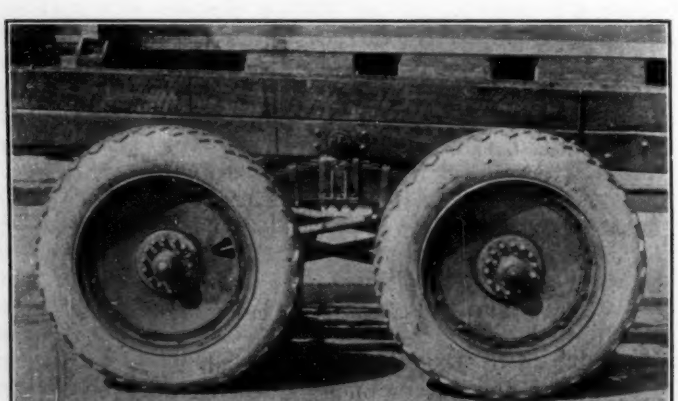


FIG. 9

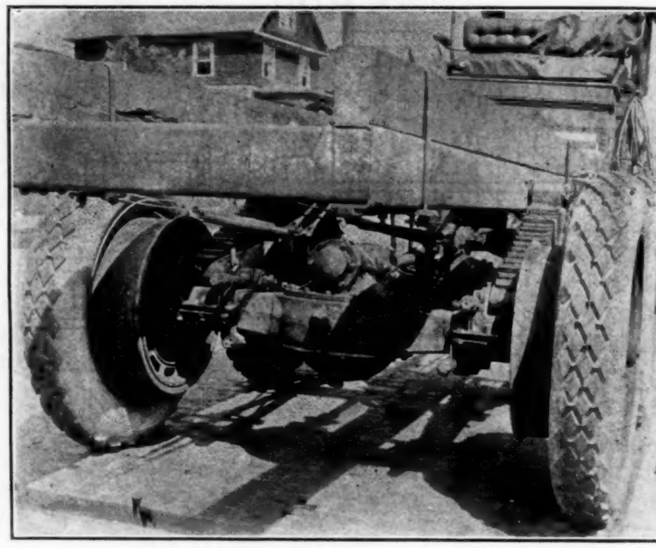


FIG. 10

TABLE V

	Lb.
Weight of 5-ton truck axle, exclusive of brake-drum	1,660
Weight of two 1½-ton solid-tire axles, exclusive of brake-drum	1,200
Saving in axle weight	460
Saving in weight of tires	520
Total saving	980
Less excess wheel and brake-drum weights	77
Net saving in weight due to use of 8-in. tires	903
Saving in weight of radius-rods, springs, etc.	300
Net total saving in weight	1,203
Weight of two 48 by 12-in. solid tires and wheels	1,262
Weight of four 40 by 8-in. pneumatic tires and wheels	1,208
Excess weight of solid-tire equipment	54
Saving in weight of axle	460
Saving in weight of springs, radius-rods, etc.	300
Total saving over solid tires	814

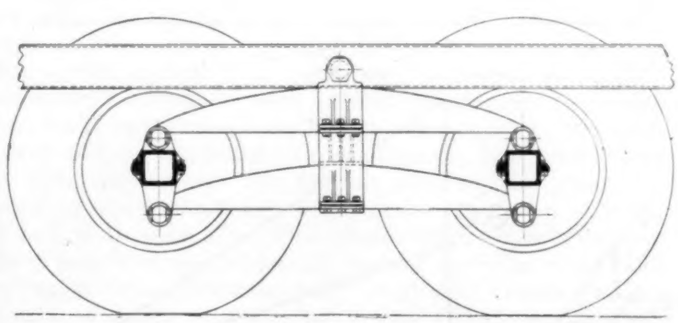


FIG. 11

tion of bodies upon the chassis to one-fourth that with ordinary construction. Thus, by reducing shocks and vibration, the number and cost of repairs, due to crystallization, fatigue of metal and the like, is reduced by a large percentage. The tandem construction makes for such exceptional riding qualities that a glass, filled to within an inch of the top with water and attached to the

(*Concluded on page* 398)

Pneumatic-Tire and Motor-Truck Development Experiences

By M. D. Scott[1]

Cleveland-Detroit Sections Paper

AFTER experimenting with large pneumatic tires for 3 and 5-ton trucks, beginning in 1907, our testing facilities up to 1917 had been confined to local trucks on short hauls only. In February, 1917, we were instructed to expand this development work on larger-sized tires with a view of determining the possibilities of large pneumatic tires on long-distance transportation, the idea being that the larger-sized motor-trucks would soon be a weighty factor in long-distance transportation, but that before they could become a factor worthy of consideration from a transportation standpoint it would be necessary to develop a pneumatic tire for this type of truck, because we were also interested in knowing what the possibilities were in motor-truck transportation over long hauls. The Akron-Boston route was finally decided upon, as we could get loads both ways. Also, we considered this a desirable route in view of the varied condition of the roads. We all realized at this time that we had a problem of truck development as well as of tire development.

Our first job was to get a truck suitable for this work. We immediately set out to interest truck manufacturers in building a special job. We were thoroughly convinced from past experience that the standard trucks built at that time were not suitable for the work we had in mind, as one of the very important requirements of this work was to get a truck with a maximum speed of at least 30 m.p.h., because time is the important element in any transportation. It was not only a question of transportation with us; we wished also to test these tires at high speed and continuous running. We put our proposition before a number of truck manufacturers and were turned down. They refused absolutely to build anything in the way of a special job for this work, as the time allotted for starting it was very short. We simply did the best we could, which was nothing more than a standard 5-ton job. We finally persuaded the engineers to agree to increase the speed of the engine to 1600 r.p.m., thereby giving us a truck speed of approximately 27 m.p.h. This was done, of course, on condition that we waive the usual guarantee; they were convinced the job would not stand up. They certainly knew the weaknesses of their engines as was proved on the first trip. It was also necessary for us to design a body for this service, as it was imperative that we have a cab suitable for a man to sleep in with some degree of comfort.

The initial trip of the Akron-Boston express began April 7, 1917, and after many difficulties with mechanical troubles, tires and roads, it ended in Boston April 24, the total lapse of time for the one-way trip being 18 days. Most of the mechanical troubles which caused the delay were corrected upon arrival in Boston, and the return trip to Akron was accomplished in 7 days. Development along these lines over a period of 2½ years has enabled us to maintain a regular schedule for the round-trip, a distance of 1500 miles, in 5½ days. In this connection, when the idea of pneumatic tires for motor trucks was first ventured years ago, critics pointed to the fact that it takes a very large tire to support a big machine, and that when the chassis weighed so much it would leave little surplus for the pay load. We found, however, that because of the pneumatic tire the truck was spared many jars and strains, and hence could be made of very much lighter construction.

Our first large truck that was equipped with pneumatic tires was a standard 5-ton truck. It could only carry 3850 lb. on the 15,800-lb. truck. The tires were 38 x 7-in. front and 44 x 10-in. rear. Gear ratios were: High, 9.33 to 1; third, 13.85 to 1; second, 24 to 1; low, 42.8 to 1. Engine size, 5-in. bore, 5½-in. stroke.

To remedy this manifestly unequal proportion we next took a 3-ton chassis equipped with a 5-ton truck engine. The truck complete weighed 12,700 lb. and carried a pay load of 4800 lb. The tires were 38 x 7-in. front and 44 x 10-in. rear, being the largest sizes then made. Gear ratios: High, 7¾ to 1; third, 11.51 to 1; second, 19.92 to 1; low, 35.6 to 1. Engine size, 5-in. bore, 5½-in. stroke.

Progress being still necessary, a 3-ton chassis and a 5-ton truck engine were used. This reduced the body weight 800 lb., bringing the total weight down to 11,900 lb. and so increasing the pay load 1000 lb. The tires were 38 x 7-in. front and 48 x 10-in. rear. Gear ratios: High, 7¾ to 1; third, 11.51 to 1; second, 19.92 to 1; low, 35.6 to 1. Engine size, 5-in. bore, 5½-in. stroke.

The truck was still too heavy in proportion to its load. Again, with a 3-ton chassis equipped with a 5-ton truck engine, by the elimination of surplus truck and body weight we brought the total weight down to 10,500 lb., which permitted a pay load of 6800 lb. Here we took 1500 lb. off the chassis and body and added 1000 lb. to the pay load. The tires were 38 x 7-in. front and 48 x 10-in. rear. Gear ratios: High, 7¾ to 1; third, 11.51 to 1; second, 19.92 to 1; low, 35.6 to 1. Engine size, 5-in. bore, 5½-in. stroke.

Our final experiment to date is a truck which weighs ready to load 4 tons complete. It is composed of a 2-ton chassis, a 3-ton truck engine and is mounted on 38 x 7-in. front and 42 x 9-in. rear tires. This has been my idea for some time past as to the proper weight of a truck and the proper sizes of tire to carry a 3 to 3½-ton pay load. Gear ratios: High, 7¼ to 1; third, 10.76 to 1; second, 18.65 to 1; low, 33.3 to 1. Engine size, 4½-in. bore, 5½-in. stroke.

Table I on page 376 gives a summary of the development obtained over a period of 2½ years. Picture a truck weighing 15,800 lb. and carrying a pay load of 3850 lb., as against a truck weighing 8000 lb. and carrying a pay load of 7000 lb. This has all been brought about through the use of pneumatic tires, thereby being able to carry a much heavier load on a much lighter truck and, as pointed out before, on a smaller sized tire, automatically increasing the earning power of the truck.

[1]Goodyear Tire & Rubber Co., Akron, Ohio.

TABLE I.—SUMMARY OF PNEUMATIC-TIRE ACCOMPLISHMENT[2]

Body and Chassis Weight, lb.	Pay Load, lb.	Increased Pay Load; Decreased Ton-Mile Cost, per cent.
15,800	3,850	(Basis, 100 per cent.)
12,700	4,800	24.7
11,900	5,800	50.6
10,500	6,800	76.6
8,000	7,000	81.8

[2]Period, 2½ years.

But the end is not in sight. We have only succeeded in proving that commercial trucks are uniformly built unnecessarily heavy for use with pneumatic tires and that, when pneumatic tires are used, weight can be materially reduced and the pay-load capacity increased. We have also shown that the lessening of the weight in turn allows the use of a smaller and less expensive tire for the increased pay load. We prove that more can be carried on a light truck when it is hauled on air, and that pneumatic tires permit a light truck to haul a larger load. This all helps to sustain our contention that pneumatic-tired trucks will use less gas, have smaller repair bills and generally give better satisfaction, as listed in the accompanying reports which show what has actually been accomplished in freight and passenger transportation. Table II shows the comparative efficiency of the first 3½-ton special standard and the latest revised truck of the same capacity, each having pneumatic tires of the sizes given. The former has a 5-ton truck powerplant and the latter a 2-ton chassis, with a 3½-ton truck powerplant.

TABLE II.—COMPARATIVE TRUCK EFFICIENCY

Details	Truck Standard	Truck Revised
Chassis weight, lb	12,700	8,000
Pay load, lb.	4,800	7,000
Front tires, in.	38x7	38x7
Rear tires, in.	44x10	42x9
Mileage, Jan. 1, 1918, to Sept. 30, 1919	79,220	......
Mileage, Feb. 1, 1919, to Sept. 30, 1919	......	16,430
Gasoline consumption, miles per gal.	4.5	6.8
Oil consumption, miles per gal.	67.7	178.6

PNEUMATIC-TIRED TRUCK SERVICE

In January, 1919, large pneumatic-tire development and motor-truck construction especially adapted for heavy pneumatic tires had progressed to such a point that we felt a transportation method could be inaugurated for profitably hauling freight for factory production from Akron to Cleveland and return, in comparison with freight or express routes. We therefore began active operation of a line known as the Wingfoot Highway Express, Jan. 1, 1919, using all available heavy-tonnage trucks to carry on this work. Approximately 550,000 lb. of freight was moved in January, or a total of 19,325 ton-mile hauling over an average round-trip distance of 79.2 miles. By April 30 we were operating daily between these points six of our large improved-type pneumatic-tire-equipped motor-trucks and had moved during this month 1,450,704 lb. of freight, or a total of 32,483 ton-mile hauling. We continued to expand and are today operating eight trucks between these cities, including one solid-tire equipment with which we desire to get the comparative costs of pneumatic and solid tires. In the month of October, 1919, 2,800,793 lb. of freight was moved between these centers, or a total of 44,421 ton-mile hauling.

Table III is a summary of the past six months' operation on this fleet. It conclusively proves the practicability of large pneumatic-tired trucks as a transportation method, in comparison to railroad hauling over short distances. The efficiency and financial statement of the fleet from April 1 to Sept. 30, inclusive, 1919, is on a basis of \$0.45 per 100 lb. outbound tonnage and \$0.50 minimum charge for packages under 100 lb.; \$0.40 per 100 lb. inbound tonnage, and \$0.30 minimum charge for packages under 100 lb. The routing is between Akron and Cleveland. Mile and ton-mile costs include the expense units of gasoline and oil consumption; drivers' labor plus necessary supervision; depreciation; maintenance, including mechanical labor, and parts; together with supervision, rent of the home office and garage; interest and insurance covering the full investment; consumers' tire cost, and general administration of the home office, licenses and taxes.

Table IV shows the comparative cost and efficiency of two 3½-ton twin trucks, running on pneumatic and on solid tires respectively, the routing being between Akron and Cleveland. The operating period was 68 days, during September, October and November. The trucks worked 65 days, without being idle, and were laid up for repairs three days each.

PROGRESS AND DEVELOPMENT OF GOODYEAR HEIGHTS BUSES

From December, 1917, to October, 1918, the population of Goodyear Heights was approximately 3000, of which 65 per cent lived on the Old Heights and 35 per cent on the New Heights. Through this period our garage operated one bus only, routed on the Old Heights and utilizing only slightly the improved pavements then in effect on the New Heights. The single-trip distance was 1.3 miles. This bus hauled 456,657 passengers in 39,289 single trips during the period mentioned. It worked 335 days of 19 hr. each, making three round-trips per hour. An allowance of 1 hr. per day was credited for total repairs and unavailable time. It was the policy of the Goodyear company to operate this bus line on a no-profit-or-loss basis. The statistics compiled showed that 75 per cent of the total revenue was for regular tickets at 3⅛ cents, 20 per cent for cash passengers at 5 cents and 5 per cent for factory passes credited at 4 cents each. This bus showed a net profit of 8 per cent on the gross investment, or 3 per cent on the total operating cost, with an average cost of \$0.313 per mile during the entire period.

During the period above mentioned considerable road work, residence building and property lay-out progressed, so that on Jan. 1, 1919, approximately 5000 people resided on both the Old and the New Heights. At this time one bus was not sufficient to move the increasing populace, many of whom were now living on the New Heights, and by Jan. 15, 1919, the garage had in active operation three buses, with a run lengthened from 1.3 to 1.6 miles single-trip distance. For such additional service and added convenience, it was necessary to put into effect Feb. 1, 1919, a fare increase of 28 tickets for \$1 when purchased in such quantities and 6 tickets for 25 cents in smaller purchases. The 5-cent cash fare remained in effect as before.

This movement resulted in property demand throughout the Heights; road improvement continued to expand and residence building expanded in like proportion. The

TABLE III—WINGFOOT HIGHWAY EXPRESS

Year 1919	Trucks Actively Operated	Fleet Mileage	Total Ton-Mileage	Through Loading Capacity, per cent	Operating Cost	Overhead Cost Cleveland Terminal	Total Operating Cost	Cost		Pay Loads Hauled, lb.	Revenue	Profit	Truck Efficiency, miles per gal.	
								Per Mile	Per ton-mile				Gasoline	Oil
April	6	12,066	32,483	78	$5,089.03	$654.28	$5,743.31	$0.42170	$0.15670	1,450,704	$6,522.32	$779.01	....	....
May	8	14,904	37,868	78	5,905.22	689.10	6,594.32	0.39620	0.15590	1,864,235	7,962.70	1,368.38	....	....
June	9	12,984	32,242	80	5,529.95	601.40	6,131.35	0.42590	0.17150	1,674,669	7,099.30	967.95	....	....
July	8	12,613	33,365	85	5,259.04	676.53	5,935.57	0.41690	0.15760	1,733,570	7,620.46	1,684.89	....	....
August	8	13,660	36,140	81	5,545.71	629.84	6,175.55	0.40600	0.15345	1,684,181	7,331.67	1,156.12	....	....
September	7	15,479	40,185	78	5,201.38	601.16	5,802.54	0.33603	0.12940	2,083,383	9,371.69	3,569.15	....	....
Totals	..	81,706	212,283	..	$32,530.33	$3,852.31	$36,382.64	....	....	10,490,742	$45,908.14[3]	$9,525.50	...	....
Average	7.7	13,617	35,381	80	$5,421.72	$642.05	$6,063.77	$0.40045	$0.15409	1,748,457	$7,651.35	$1,587.58	5.93	143.3

[3]Gross earnings, 51.9 per cent on the investment, 26.2 per cent on the operating cost.

property valuation was automatically increased throughout the Heights, in excess of 100 per cent. The garage continued to build up its bus line to meet the constantly growing demands of the people and, by Nov. 1, 1919, was operating actively seven buses. It was planned to increase this fleet to 9 or 10 buses before Feb. 1, 1920, with the route extended to 2.1 miles average single-trip distance and without a further increase of revenue per capita.

Between Jan. 1 and Oct. 31, 1919, all buses hauled 1,334,739 passengers in 81,676 single trips. An average loading capacity was obtained throughout of 78 per cent, based on a 21-passenger bus capacity. The total slack

TABLE IV.—SOLID VERSUS PNEUMATIC-TIRE EQUIPMENT

Details	Pneumatic Tires Truck A-30	Solid Tires Truck A-33
Type, tons	3½	3½
Total travel, miles	7,054	6,548
Number of round trips	89	83
Average mileage per trip	79.3	78.5
Hauling, ton-miles	19,188	17,632
Loading capacity throughout, per cent	77.7	76.9
Costs		
Gasoline	$268.99	$293.43
Oil	15.66	40.76
Drivers	357.20	357.20
Administration	81.66	81.66
Depreciation	252.53	439.37
Maintenance, material	63.48	171.53
Maintenance, labor	49.38	93.13
Consumer's tire cost	830.96	394.19
Miscellaneous	7.50	17.00
Interest	64.94	59.56
Insurance	7.30	7.30
Rent	25.00	25.00
Total operating cost	$2,024.60	$1,980.13
Efficiency[4]		
Cost per mile	$0.2868	$0.3024
Cost per ton-mile	0.1055	0.1123
Gasoline, miles per gal.	5.9	5.1
Oil, miles per gal.	332.0	140.7
Time per round trip, hr.	4.3	5.6
Truck speed, m.p.h.	18.6	14.3
Time saved, hr.	115.7	.....
Driver's earnings		
Straight time 57.8 hr. @ $0.60	$34.68	.....
Overtime 57.8 hr. @ 0.90	$52.02	.....
Saving on ton-mile cost	$130.48	......
Net saving effected	$217.18	....
Net gain by cost reduction, per cent	10.7	....

[4]Credit not allowed pneumatic-tired equipment for additional available hours over solid tires; increased satisfaction and better personnel of drivers, with less labor turn over, value to production in effecting quicker deliveries, additional safety and fewer claims for breakage in pay loads.

travel allowance was 2554 miles. The total mileage of all buses was 139,810 miles, or an average single-trip distance throughout of 1.71 miles. The gain on the total operating cost throughout the entire period was 5.4 per cent.

TABLE V.—SUMMARY.—GOODYEAR HEIGHTS BUSES

Cost per mile	$0.38060
Cost per mile per passenger	0.02331
Receipts per passenger per trip	0.04203
Cost per passenger per trip	0.03987
Gain per passenger per trip	0.00216
Net gain, per cent	5.40
Gasoline, miles per gal.	4.82
Oil, miles per gal.	56.40
Average loading capacity, per cent[5]	78.0
Tickets sold, per cent[6]	69.7
Cash fares, per cent[7]	28.5
Factory passes, per cent[8]	1.8

[5]Bus capacity, 21 persons plus driver.
[6]Average, 26 tickets for $1.
[7]Straight cash fare, 5 cents.
[8]Credited to bus, 4 cents per ticket.

Table V is a summary of the costs, efficiency and loading capacity of these buses. The costs include gasoline and oil consumption; drivers' labor; supervision of driving; labor; maintenance, including labor and material; supervision of maintenance, and depreciation. The basis is on 80,000 miles of bus life, 2 years; $1,000 salvage value at termination; office administration, consumers' tire cost, rent interest, insurance, taxes and licenses, together with any miscellaneous expenses.

THE DISCUSSION

E. S. FOLJAMBE:—Have any tests been made in regard to the excess wear on the rear tires of the six-wheel truck because they have slight slippage when the truck is not level?

CHAIRMAN J. E. HALE:—The principal activities on this six-wheel truck were to develop the truck, putting it through much severe service. No particular attention was given to tire wear. The first chain-drive truck ran about 10,000 miles and the tires on it averaged about 4500 miles; but in practically every case they were abused. The very rough roads punched holes in the tires. There was no chance to test the tires under those conditions. The present trucks are not yet fully developed, but we have other trucks under construction. We think we have learned some of the shortcomings, and intend to test these new trucks under more favorable operating conditions.

J. W. WHITE:—Where Mr. Templin gives road speed as a final action of reduction, why is it run up; gearing the transmission so high?

E. W. TEMPLIN:—It is essentially a problem in rotating the rear wheels. It is not necessary to make the reduction all in the rear-axle, as the use of the over-gear will give the same effect. The ratios given are the ratios necessary to rotate the rear wheels and give the speed specified.

CAPT. G. R. YOUNG:—The Government is considering the pneumatic tire extensively. Mr. Shively gave the points to be considered in determining the proper motor-truck tire. Other important things to be considered are maintenance and the cost of gasoline. In war the cost is less important than in peace.

We are considering pneumatic tires for our standard 1½-ton trucks. These may be either one of the commercial makes that we have now, or perhaps a standard truck that was designed but not put into use during the war. We are considering it very tentatively for our standard truck, which involves many new designs. Some tentative designs are being made. We intend to try out pneumatic tires on this heavy truck to determine whether or not the Government can be convinced of their advantages. If we can adhere to our standardization program so that we shall have only one type of truck for any given carrying capacity and speed, and will not be forced to accept such construction as the manufacturers desire, then the Government will undoubtedly be a very large customer for pneumatic tires even in times of peace.

The standardization program of the Government involves the development of a single type of truck for each one of the four or five different sizes and speeds needed. This truck is to be as nearly as possible conventional, but with certain features added, such as increased traction and simplicity of operation, which are essential to military use. It should be a typically built-up truck, any part of which can be built at different factories. We hope to succeed with this program. It we do, there will probably be 40,000 to 50,000 motor vehicles as a peace strength, which will mean a purchase of 8000 to 10,000 vehicles per year.

In connection with suggestions for testing this six-wheel truck, I would be very much interested to see it tried out in competition with any type of four-wheel-drive truck.

CHAIRMAN HALE:—We have not made comparisons, because we have been merely developing trucks. We intend to build trucks that will be suitable for use in such tests.

CAPTAIN YOUNG:—Regarding roads, the Government has applied certain tests to road-beds; the results of some of these tests as to the impact effect of various types of truck on the road have been published. The Government plans to follow that up with a series of tests made on an oval track of various types of construction.

There has been a general agitation resulting from the tremendous wear of roads by trucks, and much effort to stop that wear in some manner. One group desires to improve the roads and the other to regulate the speed of the trucks. The industrial States will tend to build better roads; the others will put more stress on the speed and weight of the trucks. Legislation favoring low-tonnage trucks should be discouraged.

MR. FOLJAMBE:—Many States limit the carrying capacity of a truck to about 800 lb. per in. of tire width, based on solid tires. Do they consider these pneumatic tires in that class? If so, what is the allowable weight per inch of width of the tires?

A. J. SCAIFE:—I notice in Mr. Darrow's first table, a 36 x 6-in. tire is recommended for the front tires of a 3 and 3½-ton truck, and yet you use a 38 x 7-in. tire on your 3-ton trucks.

CHAIRMAN HALE:—We consider the 36 x 6-in. size gives ample tire equipment. We had these trucks equipped with the 38 x 7-in. tires and have never changed them. We have made such improvements that we consider the 6-in. tires ample to handle a 3-ton load. The development of a truck which will take a 3½-ton pay load on 42 x 9-in. tires, as shown by Mr. Scott's paper, was a commendable performance. We are now looking to Mr. Scott to develop a 5-ton truck on which we can put 44 x 10-in. tires rather than the 48 x 12-in. size. Mr. Templin's comparisons must be changed when we reach that point, but we must reduce the weight of the truck before we can do it.

E. A. HASKINS:—Regarding the small orifice in the ordinary tire valve, which is simply a continuation of the valve used in bicycle tires, it increases the time period for the inflation and it would be a great advantage to increase this tire-valve size. What has been done toward making a new kind of valve which will eliminate these difficulties?

CHAIRMAN HALE:—The problem of valves for inner tubes and tires is a difficult one. We have under test at present inner-tube valves which have three times the orifice area of the present passenger-car valves. It is fairly easy to make a valve any size desired, but a complication arises if the valve is made large; a threaded portion at the end is different from that of the standard valve. This invites trouble all over the country because the pump connections will not fit that portion.

If we could leave it to the valve-manufacturing company we might be tempted to do it, but the other companies are apt to treat it differently. A new valve has been designed very recently which seems worthy of thorough consideration. The tires and inner tubes are very well developed, but a number of auxiliaries are not worked out. The valve is one; the air-pump on motor trucks is another. Many things connected with rims are not completely developed. We are now trying to bring all accessories up to the same standard as the tires.

J. E. SCHIPPER:—On the large-size tires there is considerably more of a flat tread than on the smaller sizes; that is, the sidewall seems to be built up. Would that work out to advantage in the smaller-size tires, and has it any effect on the gas consumption on rutty roads?

CHAIRMAN HALE:—There is a flat tread and steep sidewall on the 44 x 10 and 48 x 12-in. tires. In 1917 it was decided that we should make a 44 x 10-in. pneumatic truck tire with sufficient carrying capacity to support a 3-ton truck. The greatest difficulty encountered was to prevent separation between the tread and the carcass. The first tires were made with round treads, which caused the tires to flex considerably before the necessary contact area could be obtained. This flexing, combined with a component of the vertical load on the tire, resulted in a tremendous shearing action between the tread and carcass, which in time caused the tread to separate from the carcass or tire body. The logical thing was to make the tread flat, to give the necessary contact area without so much flexing and to widen it out, which would decrease the unit stress on the union between the tread and carcass of the tire. We did that and the results have been very satisfactory.

There seems to have been an understanding among tire designers that it is not good practice to have much

of a shoulder at the edge of the tread of passenger-car tires. However, we have proved that a flat tread of the proper proportions has several distinct advantages and results in much longer tire life. As to the relative economy in gasoline consumption of the two types of tire on rutty roads, there would be a slight advantage in favor of the round tread; but when good roads are taken into consideration the advantage would be in favor of the flat tread.

J. W. SAFFOLD:—Referring to the six-wheel truck design, would it be flexible enough to stand up and be equal to the conventional truck If so, will it furnish any more flexibility than the conventional design?

MR. TEMPLIN:—To test the flexibility, we raised the forward wheels of the six-wheel truck 12 in. from the floor before we reached the limit of the universal connection. We also raised the rear wheels 12 in. We believe that 6 in. is enough for almost any condition. We have put that truck under a condition where diagonally opposite wheels were 18 in. lower than the other diagonally opposite wheels. In that condition the springs twisted, and from all appearances the rear springs were not stressed beyond anything reasonable. An authority on springs observed especially the condition of the stress of the springs, and his opinion was that it was perfectly satisfactory. In connection with the springs and the transmission, the four-wheel combination under the rear protects them to a great extent. Where the two-wheel construction bounces over the ruts in the road, the four-wheel combination will roll over them, and in that way is to some extent a protection.

MR. SAFFOLD:—Does this construction cut down the tendency to side-sway?

MR. TEMPLIN:—I believe it does. We made some short turns at high speed and the side-sway of that rear end was remarkably small in my estimation.

MR. SCHIPPER:—Will the load be concentrated on the rear set of wheels on these six-wheel trucks when the front set is raised?

MR. TEMPLIN:—When the power is applied in going forward, the forward tires are compressed and the rear tires are probably relieved under that condition. The torque momentarily applies an added load to the tires and that has a cushioning effect upon the driving mechanism.

M. D. SCOTT:—The question of whether self-locking differentials are practical was brought up about 18 months ago by a truck engineer. We purchased two trucks of exactly the same construction, except that one had a self-locking differential and the other was a standard truck. We ran those trucks over the Akron-Boston route, where we had been having considerable trouble with the worm-gear drive. It was very common to change a worm and wheel every 1000 to 5000 miles. After we had put these two trucks over the same route for some time, the self-locking differential was still on the original equipment, while on the truck with the standard differential we had made three changes of worm and wheel. In addition, we had made several changes in thrust bearings. The self-locking differential has now run 30,000 miles. At present we are using self-locking differentials on all long-distance hauling. It has a very material advantage in that respect; we have not tried it on different types of drive.

F. A. WHITTEN:—Could the truck be run without any differential?

MR. TEMPLIN:—We tried that out on this four-wheel combination and got into trouble. One of the shafts twisted off. I attribute this to the fact that we had no differential and a solid casting in the place of the differential. I am not in favor of going without a differential on a four-wheel combination; on a two-wheel combination it may work out.

MR. WHITTEN:—What special reasons are there for no-lock differentials and for locking differentials?

MR. SCOTT:—The principal reason for the locking differential is the high speed at which the trucks are driven. This can be explained by considering the number of times that a wheel leaves the ground in passing over obstructions or depressions. One wheel will leave the ground and, when it does, the wheel immediately starts to spin. When it comes back to the ground again, it must conform immediately to the speed of the opposite wheel and the strain all goes into the worm and wheel. There have been many reasons advanced for this, but the one advanced above seems to be the most logical.

MR. SAFFOLD:—The reasons for the locking differential are very good ones. One is that the ordinary differential is a compensating device and as such it is 100 per cent efficient. But as a differential it is not 100 per cent efficient. That is shown when the truck loses traction on one wheel because, when it spins, the power going through it is following the path of least resistance, and the vehicle is liable to be stalled. With the locking-type differential the power is equally applied to the two wheels. In this case it pulls out of the rut, instead of staying in; that is the chief difference. The second reason is that it prevents end skidding, if the skid starts from the differential. If that is stopped, the tendency toward skidding is prevented.

CHAIRMAN HALE:—We have recently made some experiments and found that with the wheel not turning, the engine can turn two-thirds of a revolution. At the time of making these tests, we made tests which would show the side-sway permissible. There is a very pronounced lateral displacement possible without skidding the tires on the road surface, which is sufficient to account for the fact that the six-wheel trucks can turn corners and show very little skidding.

MR. FOLJAMBE:—I was interested in the six-wheel truck a year ago. I believe that the ultimate heavy-haulage vehicle for city bus work will not be a six-wheel vehicle, but a semi-trailer-type combination having four wheels at the rear of the front vehicle, and four wheels at the rear of the semi-trailer. This can be operated by one man and would therefore be an economical proposition for bus work. There is the problem of whether it could be made to go around corners properly without differentials in the axles, and without in any way swiveling and pinioning. Experiment will ultimately show whether that can be done or not. Mr. Templin and I believe it should have the differential, but further tests will bring out these details. I know that all engineers are interested in this problem. I believe that the electric traction lines will be replaced largely by the motor-truck bus-lines. The pneumatic tire will make that possible.

MR. WHITTEN:—The six-wheel truck is too new to offer criticism from the outside. The builders have not had time enough to know their own minds about what it will do. Possibly there are one or two things that have not been given the consideration they merit. We sell many trucks with pneumatic tires; more than 50 per cent are for use on bad roads. That is further borne out by the fact that many of the orders for pneumatic-equipped trucks specify not the standard gear ratio but one 25 per cent lower. The demand for pneumatic tires comes with a demand for a 12 to 1 gear ratio on 2-ton trucks.

Have any tests been made to determine what the trucks geared to run 30 m.p.h. with a large engine will do in city travel? Is this truck limited to one particular use?

Gasoline and oil-consumption comparisons hardly seem fair. The pneumatic records have been made on trucks with tires which have been developed for this purpose. The commercial solid tire has been made to sell. The efficiency varies tremendously. That may possibly be due to variations in tire manufacture. The tires used on electric trucks have to be made of an entirely different compound. So far as we have been able to determine, the highly efficient solid tire does not give any reduced mileage. Under equal conditions it gives better mileage. There is also a possibility for the development of the solid tire. We have run a few S.K. tires and have had remarkable results. That tire has great possibilities for city work.

In connection with pneumatic tires, the demand comes from people who want to put these tires out in the country where there are no good roads. They buy them because they cannot get there with the solid tires. But they soon find that operating trucks under those conditions is hard on the truck tires, engine and every other part of the chassis and body. That immediately brings about a demand for a good road, with a foundation and with good surface. With the ultimate road of that type, what sort of tire will be used? The trend toward the pneumatic tire may change in time because of the changed condition of the road surface. The locomotive with its steel track and steel wheels gets satisfactory running under most conditions. It will be a long time before we have the type of road which the railroad now has, but the smooth hard road appears to be the ultimate road. If that is the case, would not the solid tire serve well?

MR. SCOTT:—Regarding the 30 m.p.h. truck designed for pneumatic tires, its efficiency and the speed at which it must run in city streets, this is a question of the efficiency of the large engine in comparison with the small. Practically all of our experimental work has been over long runs. By using a 5-ton truck engine to draw a 3-ton load we found that this engine was more economical than that of the $3\frac{1}{2}$-ton truck. This is because of the ease with which the large engine does the work. Over the mountains the smaller engine was working at a maximum. A very close check on that showed a 0.7-mile difference in gasoline consumption of the larger engine over the smaller.

City work is dependent upon the stops to be made. Many trucks stop often; with these we can get about 2 miles per gal. of gasoline. With that same truck outside of the city, we can get 6 miles per gal. An average on all the buses shows about 5 miles per gal. of gasoline with a 2-ton chassis. But that is not low mileage, because of the unusual number of starts and stops.

The same thing holds true with the larger or smaller-type engines. We use the larger-type engine on trucks for heavy grades. We found that the same things held true there when we used a 30-hp. engine. Our first trucks for such routes had 30-hp. engines, but they made no better mileage than the 45-hp. engines.

CHAIRMAN HALE:—The efficiency of solid tires as far as absorbency is concerned depends entirely upon the formula used in compounding the rubber. It is possible to have a wide range in the efficiency of the rubber stock. There seems to be a very positive indication of a very satisfactory saving of gasoline in the use of the pneumatic as compared with solid tires. Many instances bear this out. The abstract reasons of just why this is so are probably very far-reaching and possibly we are not in a position to give them at present.

MR. FOJAMBE:—In regard to the tendency toward or away from pneumatic tires when we get good roads, it seems that the tendency toward pneumatic tires will be increased under those conditions. With good roads, speeding is the next thing desired. Even on good roads the desired speed cannot be attained with a solid tire. There never will be a time when all roads will be improved. Even with a highly-improved highway system the truck must occasionally leave the hard surface, which again requires some kind of tire other than a solid one.

CHAIRMAN HALE:—The speed at which the pneumatic-tired trucks shall be operated must be controlled entirely by the safety at which they can be operated. We have found that 25 to 30 m.p.h. is satisfactory; it is very similar to passenger-car speed.

R. HUFF:—Regarding the six-wheel truck construction suggestion, I have had some experience with pneumatic tires on small 1-ton trucks. It is customary with most manufacturers of 1-ton trucks to use the standard touring-car track, namely 56 in. from center to center of the tires. My experience has been that the use of pneumatic tires on these trucks raises the center of gravity of the load so high that there is a serious tendency for the truck to tip over when making sharp turns rapidly or on highly crowned roads. A lower center of gravity which might be obtained by a six-wheel truck construction would be an advantage in this respect. In the case of heavier trucks, the six-wheel type would hold the advantage that, in cases of changing tires, it would be easier for a driver working alone to change the smaller tire required than is the case now where he is obliged to change one of the extremely large-sized tires.

In connection with the use of pneumatic tires on trucks, what type and what capacity of jack have been found to be most satisfactory? My own experience with jacks in general, when used on pneumatic-tired trucks, has been most unsatisfactory. An overload with a flat tire is extremely hard to handle. I find it very difficult to get a jack which is low enough to go under the axle in this case and still have range of lift sufficient to raise the axle high enough to permit handling the tire. How far can a man drive an overloaded truck with a flat tire without ruining the casing? I ask this because I have had experience with drivers who brought in brand-new casings that were absolutely ruined, although they had been driven only a few miles. In this case the drivers claim that they found the tire flat and did not know it was flat until they had driven some distance.

Regarding the discussion that a high gear ratio and a large engine should be used with pneumatic-tired trucks, experience has demonstrated that a high gear ratio is not desirable in trucks which are running exclusively in cities and much of the time in thick traffic. Many of the cities have ordinances limiting the speeds of 3 to 5-ton trucks to 10, 12 and 15 m.p.h. A driver is automatically limited when in traffic to a speed sometimes lower than this, and he would be obliged to run in intermediate or low gear most of the time in city work if his truck were equipped with the proposed high gear ratio. It therefore seems to me that it will always be necessary for manufacturers to build two different types of chassis, one with the high gear ratio and large engine for pneumatic-tired trucks for cross-country work and another with a low gear ratio and small engine for solid-tired trucks and pneumatic-tired trucks to be used exclusively on short hauls in city traffic.

There has been considerable talk to the effect that the pneumatic-tire equipment for trucks would completely supersede solid-tire equipment, with the claim that the pneumatic tire rides so much easier that the truck chassis will stand up better than it would in the case of the solid tires. No doubt this is true in the country when driving at high speeds, but it has been my experience that heavy trucks in crowded city traffic on short hauls last practically indefinitely when run on solid tires, because the nature of the service and the traffic conditions prevent the truck from running fast enough to develop any serious vibration. I feel that there will always be a large field for solid tires for heavy trucks in city work.

MR. SCOTT:—We use two jacks, one large and one small. One jack alone has not enough lift to take the tire off the ground; it simply takes most of the weight off the tire. After that we use another jack. Some jacks are all right for small trucks, but the 3½ and 5-ton trucks are another problem.

W. E. SHIVELY:—To get out of a mud hole in case a tire becomes flat it is not necessary to drive very far. At low speed the tire would stand that amount of running without any harmful effects. There is a tremendous strain on the tire, but the speed has much to do with that. The only harmful effect would be in case the driver did not know when the tire went flat. I believe that is not a very serious objection.

MR. TEMPLIN:—In regard to the gear ratios given in my paper, I had to take trucks under average conditions. For use within city limits, I would myself design buses with gear ratios corresponding to the present practice with solid tires. On a bus operated between Akron and Cleveland I would put the extremely low gear ratios, such as 5 to 1, because 90 per cent of the mileage would be at such ratios. There would be only about 10 per cent on the high ratio.

MR. SCAIFE:—Like many others, when the six-wheel vehicle was first presented, I considered it a freak. We have a tendency to be rather skeptical of the practical application of the vehicle. I believe there will be a field for that vehicle. Bus lines will be looked forward to, to replace the street-car of the present day in large measure, and there will be a field where a vehicle of this kind will be very valuable in solving some transportation problems. The four-wheel vehicle will have a large place in transportation for some time to come.

E. T. BIRDSALL:—It appears to me that one of the first things to be done is to redesign the engines. When the Akron-Boston express route was first started, I noticed that almost the first thing they did was to put a 5-ton truck engine in a 3-ton truck, to get the necessary high speed. Truck manufacturers all seem to have an antipathy to an engine that runs over 900 r.p.m. With this limitation the engine designer has a hopeless task. We must get away from the ordinary truck engine. It is possible, feasible and practical to build a truck engine that will run normally at 2500 r.p.m. and this will obviate many troubles with gear ratios, because the engine will run at high efficiency at low truck speeds in the city, as well as at high speed in the country. The pneumatic truck tire will, I believe, force the truck manufacturer to use that type of engine. It will cost more than the ordinary engine, but it will work at a higher efficiency. We cannot do it all at once. The main consideration seems to be a pneumatic-tired truck making long hauls, doing a large percentage of high-speed and high-gear work and a small percentage of the intermediate and low-speed work. There will be customers who will want to do other things under other conditions, and the type of engine I mention is the only one that will give satisfaction in such cases. It is very difficult, however, to get the truck and engine manufacturers to take so large a step at once.

F. A. SEIBERLING:—Are the things we have been talking about actualities or dreams? Has this six-wheel truck any merit? I was hoping that Mr. Templin would stand for the extreme idea. He said he was willing to admit that the differential ought to come in. When I think, for instance, of the 5-ton truck running on a smooth pavement, I contend that the six-wheel truck, as we have developed it here, without the differential, has a place. Am I right or wrong?

S. G. THOMPSON:—There is nothing new in the use of six wheels with tandem rear drive as produced here. The experiment has been made several times in the past 20 years. There is much to consider in connection with Mr. Seiberling's remarks regarding bus-line development, and whether there will be a trend toward pneumatic tires that will ultimately resolve itself into an economic proposition. In discussing the general use of pneumatic tires for heavy motor trucks, it must be remembered that their principal advantage is higher average speeds. Whether this higher speed is generally obtainable to the extent of resulting in an increase in the value of the service rendered is another question which is subject to speculation, especially if we consider that, at best, freight movement by motor truck is largely confined to city areas and inter-city hauling is limited to a small percentage of the gross railroad tonnage of the country. For example, low-rate freight comprising the products of mines, agriculture annuals and forests represents 77 per cent of the total tonnage of the railroads, and moves average distances of from 133 to 335 miles. High-rate freight comprising the products of manufacturing and merchandising is only 23 per cent of the total tonnage and moves but a comparatively short distance, as is shown by the fact that the average freight haul for all classes of commodities is only 167 miles and but 138 miles in the Eastern district. These statistics lead me to believe that inter-city motor-truck hauling is apt to be limited to distances where perhaps the "value in service" of large pneumatic tires will be difficult to establish.

MR. BIRDSALL:—I see great possibilities for the development of this six-wheel truck. My original business was operating a street railway in a certain city, so I can state the comparative advantages of the bus over the street railway. The initial investment for a street railway is extremely high. A number of street railways have gone out of business recently. One company has taken down all its trolley wire and poles and sold them. On two roads that I had built, they had a strike and went out of business. I believe that the tracks in the streets of congested districts must be eliminated.

H. B. KNAP:—On trucks in general it appears that solid tires will be used in cities for short-haul hard-road low-speed work. Pneumatic tires will be used for high-speed long-haul conditions and for soft-road rough-country conditions. In other words, the added expense per mile of the pneumatic tire must be offset chiefly by making more trips per year, either by virtue of higher permissible speeds or by being able to negotiate soft roads and ground where solid-tire equipment cannot operate.

If the manufacturer builds more pneumatic-tired trucks than there is a correct market for, he runs the risk of having some of them sold where solid-tire equipment would be preferable, which would be a set-back for the

use of pneumatic-tire equipment. It is therefore believed that the production requirements should be very carefully estimated, and that the selling of pneumatic tires should be closely supervised. In this connection the lowering of the solid-pneumatic price differential would be of great help in the education of truck operators.

As to cushion tires, it seems that some of them are about half-way between solid and pneumatic tires in resiliency, and therefore do not have so much effect on permissible speeds, or on traction in soft going.

L. P. KALB:—Many engineers connected with the motor-truck industry are beginning to realize the broadening effect that pneumatic tires will have upon the truck field. It would, therefore, be foolish for anyone to oppose this trend. The six-wheel truck may have shown us the way to overcome what was formerly considered one of the greatest drawbacks to large-sized pneumatic-tired trucks. It has shown that the solution of the problem is not impossible. However, we must forget our solid-tire prejudices if the pneumatic tire is to be used to the fullest advantage. We must start with a clean slate and develop things along different lines. Whether it will be a six or a four-wheel truck, I hesitate to state. It will require much development and those who go into it early will reap the fruit, while those who lag will suffer.

J. A. KRAUS:—Prospective buyers of motor trucks, not having had previous experience with motor vehicles, naturally expect that the solid tire will give 50,000 miles and feel they are getting something better in the solid tire. The various designs of cushion wheels are an answer to the shortcomings of the solid tire.

The discussion indicates that most trucks are operated in large cities where there is solid pavement. We have an increasing demand for trucks for use in foreign countries. This demand is at present very great. It is surprising that in Africa, Australia, Java and other places they are asking for pneumatic tires. We have received an order for 300 trucks to be equipped with front and rear pneumatic tires. Certainly the purchasers knew what they wanted. We have had enough experience with pneumatic tires to draw a comparison. Experience with solid tires has shown that very frequently the chassis, especially the engine, suffers greatly from shocks; the vibration is considerable. A certain model was produced and equipped with pneumatic front tires; a square gasoline tank was used. Later, a revision of this model brought out solid tires on the front. The pneumatic-tired models gave good service, nearly 100 per cent, but the gasoline tanks on the solid-tired trucks had to be replaced.

Relative to the multi-wheel vehicle, we should not give much consideration to semi-trailers. Many overlook the danger with these when turning corners on down grades, and applying the brakes at the same time. They will fold up like a jack-knife. With the short tractor with a two-wheel trailer, when turning corners on a wet street, the back end comes around too fast and results in loss of control of the steering. The semi-trailer has convinced me that the multi-wheel truck of the future will be of the type that the Goodyear company has developed. It must be admitted that the smaller size of wheel and the reduced weight of the tire will prove a great benefit to owners and drivers.

MR. THOMPSON:—The field for heavy-duty pneumatic-tire trucks appears to be very limited. The best argument I can find for the solid tire is contained in the papers that have been presented. In Mr. Templin's paper we find what purports to be a table of comparative performance, in which several units are considered. To me this table appears to be simply a statement of results obtained under certain operating conditions, controlled by certain factors. It does not appear that this is a comparative analysis in any way, for the reason that for each investigation all of the factors were changed. If an investigation is being conducted to determine the results to be obtained by the use of one device in comparison with the use of another device designed for the same work, the only factors which should change are the factors controlled by the device. To change the tire factor and leave all other factors the same would give comparable conditions.

The operating-cost table appearing in Mr. Scott's paper shows that the cost per ton-mile for the pneumatic tire is $0.1055, while the cost for the solid tire is $0.1123. However, if we examine the items which are included in these costs, we find that in the case of the pneumatic-tired truck depreciation is based upon approximately a 20-year life, while in the case of the solid tire depreciation is based on what is known today to be the established life of a truck operating under those conditions. In view of the fact that 68 per cent of the truck manufacturers have been in business less than five years, how can the depreciation be based upon a 20-year life? As we have not enough evidence in the industry today to support the claim for a 20-year life, it would seem to me to be advisable to eliminate the depreciation charge. If depreciation is omitted, or if amortization is placed at a definite period, the saving shown disappears entirely; so it would appear that the table is merely a selection of the bookkeeping methods to prove the case.

Let me call attention also to the item of interest which I notice in the cost tables and which should not appear as an item of operating expense. The only reason that motor trucks are used is because they have an earning value. They are more economical than other means of transportation. The sole reason for making an investment in a motor truck is to avail oneself of its earning value. Consequently the earning value of the investment is the reason for the investment and that in itself constitutes the interest. If the earning value was not sufficient to earn the same amount of interest that the money might earn when placed in sound securities, there would be no reason for making the investment. Consequently interest is not an operating expense. This is something the motor-truck industry should consider.

G. J. THOMAS:—The multi-axles on the six-wheel truck are well worth developing. Being a four-wheel-drive engineer, I might say that the four-wheel drive has really never been fully developed. We must distribute the weight more evenly and reduce the entire load. The only way is to distribute the load over a large number of wheels.

This six-wheel truck is very similar to a truck we built some six years ago, but the truck we built had a six-wheel drive. It was a dream of a lumber man who bought a four-wheel drive and had to pull it out of a mud-hole with ox teams. This truck has been run for six years steadily in the logging business, carrying logs. It was built with steel tires all around and has been very successful. I believe it proves that the Goodyear company is on the right track. I think that within five years trackless street-cars will be built with eight drivers. I believe that is possible, more especially since I have seen the demonstration of the six-wheel-drive truck in Akron.

L. M. BAKER:—Regarding the six-wheel-drive truck, I admit that I have had a more comfortable ride in one on a solid board than I have had in many touring cars with spring seats. It strikes me as being a very good

thing for work up and down the street as a bus. For pulling in and out of foundation holes, hauling contractors' supplies and other heavy truck jobs, I think it would not do so well because of the fixed condition of the two rear axles. It struck me after I had seen it that this truck would to a certain extent replace the street car.

MR. DARROW:—The question of solid and pneumatic tires can be argued only on two counts. The first is reliability. We can expect 7000 miles and over from pneumatic tires. During the life of each tire we can expect to remove it once from necessity, and perhaps other times for treatment. With average mileage and care we must remove one tire per month.

The second point is cost. The first-class improved highway of concrete, with a deep foundation, costs $40,000 per mile. Mr. Seiberling mentioned that there are 200,000 miles of more-or-less improved highways in the United States. This runs up to $8,000,000,000. If we ever get highways of that character, the element of depreciation on roads must be included in the cost of pneumatic tires.

In regard to unit load, there is a limit to the weight that can be carried on solid tires per inch of tire width. As a matter of fact, this is not the right way to measure it; it should be pounds per square inch of contact area. With pneumatic tires, the load per each square inch of contact area is equal to the inflation pressure. As to the cushioning, a solid tire deflects about 3/8 in. A pneumatic tire deflects 3/4 in. or more. We have only one-quarter the impact with one-half the load, per square inch. Those things have a bearing on the maintenance of the foundation of the road. The road is the expensive part. We must keep in mind that solid tires will injure the foundation of the road and that the investment involved in keeping the roads in repair is tremendous.

To sum up and connect three things together, in a pneumatic-tired truck we have a saving in the truck itself, an increased efficiency and a large saving in roads. Taking into consideration only the initial tire cost and mileage delivered, we cannot show that pneumatic tires are more economical but, considering these other things, there is no question that pneumatic tires excel solid ones.

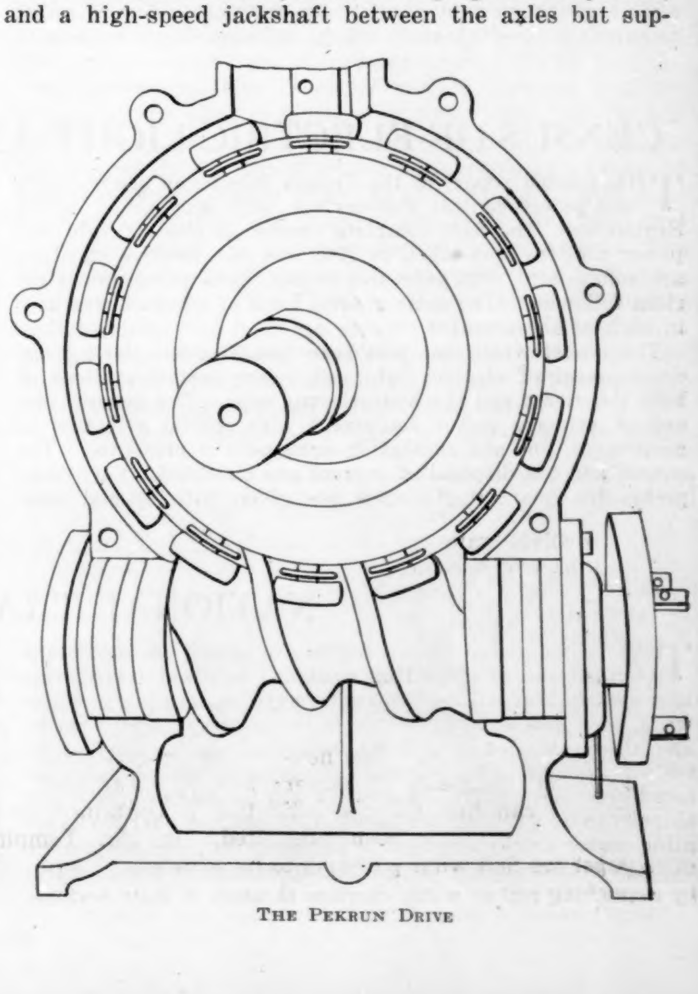
JOSEPH SCHAEFFERS:—Considering the future prospects of large-size pneumatic tires, it appears that the weight will prove the main limiting factor. A driver and his helper can handle a tire with rim below 200 lb., so that the 40 x 8-in. tire would still be practical, while the 48 x 12-in. tire, weighing with rim about 500 lb., can hardly be handled by one or two men without involving undue effort. In exceptional cases the very large sizes may be justified and establish a field of usefulness, but for general adoption they appear to be too heavy and too expensive.

The question of rim equipment on pneumatic-tired trucks is merely a question of efficiency against convenience. The detachable rim equipment is lighter; it is therefore more efficient and results in longer tire life. On a passenger car, the greater convenience for the owner-driver in having an inflated tire on the demountable rim is worth the extra cost. But as Mr. Darrow pointed out, the tires are good for at least 7000 miles and one need not figure on more than one change of tire per month. What is the difference in weight between the detachable and the demountable equipment? How much does that difference in unsprung weight affect the tire life? Is it worth while to save possibly 15 min. once a month for the driver, at the expense of lower efficiency for every ton-mile?

The distribution of the main load over four rear tires as accomplished in the tandem rear axle is certainly worth a very thorough test. In July, 1911, at the Dayton S. A. E. meeting, Mr. Reeves demonstrated an eight-wheel passenger-car. It was an easy-riding car, but the economic necessity was not there, certainly not to the same extent as at this time for commercial vehicles.

It is impossible to judge, at this stage, to what extent the tire life will be affected by the fixed position of all four driving wheels. If the wheelbase is long enough and the drive-wheels set as closely together as possible, the extra tire wear may be negligible. Only tests covering several ten thousands of miles on a comparative basis can demonstrate this. Just because six-wheel trucks were not successful years ago, it does not follow that they will not be successful. E. R. Hewitt built an eight-cylinder V-type engined passenger car some 12 years ago. The fact that he abandoned that design does no prevent the present V-type eight-cylinder car from being a success.

In reference to the design of tandem rear axles, it seems that the worm drive would here be even less appropriate on account of the much wider range in speeds. The worm drive, if used, should of course have a proper amount of bearing surface between the worm and the wheel. Shock loads, as well as a continuous application of maximum loads, break up the oil film between worm and gear and cause metal-to-metal contact with incidental wear and destruction, as was evidenced by the worm gear with standard gear differential, mentioned by Mr. Scott. The only worm gear drive which provides rolling contact between worm and gear is the Pekrun drive, shown below. However, a tandem rear axle gives an excellent opportunity for chain drive, using two dead axles of I-beam section, made of high-grade alloy steel, and a high-speed jackshaft between the axles but sup-


THE PEKRUN DRIVE

ported above the springs. By a judicious use of the newer light metals such as duralumin or electron, the weight of hubs, wheels and rims can be cut down to about one-third of the present weight. The total unsprung weight of such a design would be only a small fraction of the weight given in Mr. Templin's paper.

The jackshaft bevel drive should be used if possible with a double transmission arrangement, one high-speed direct for country roads and one low-speed direct for city traffic and for bad roads, with about 30 to 35 per cent difference between the two, and giving a choice of six speeds with a three-speed gearset. A straight line drive should be used, eliminating power losses in universal-joints. The running of such a tandem axle and a single-drive axle for some 50,000 miles on a comparative basis should tell an interesting story. The jackshaft should by all means carry a self-locking differential.

MR. WHITTEN:—I asked one of our dealers about his trucks and if he was doing any cross-country hauling. He said he had come to buy two more trucks for 80-mile long-distance hauling. I asked if he intended to have pneumatic tires on these trucks, and he told me he had no use for the pneumatic tire; that there was a new State highway on the entire route, that he had no trouble in making the 160 miles per day on solid tires and that he felt he gained nothing by using pneumatic tires. That led me to bring up this question of roads.

L. C. ROCKHILL:—I am apt to look at this problem from a merchandising rather than an engineering standpoint. If a thing is needed from the standpoint of public service, the engineering fraternity works the thing out. However, I think that sometimes we confuse the issue in discussing the virtues of pneumatic and solid tires on large trucks, by thinking too much about what is past and not enough about the future. I have never been able to enthuse very much over the possibility of using pneumatic tires on such trucks as have been used with solid tires for years past, or over the truck market as it has been in the past. The thing that interests me primarily is the possible truck market in the future. I think that there are tremendous possibilities for the use of large trucks in new fields of endeavor and that they are almost solely dependent upon the use of pneumatic tires. Something must be done to make the large trucks more useful in filling our transportation needs. Large trucks have run on pneumatic tires from Akron to Boston during a period of more than three years. I suppose that those trucks are not particularly economical in that service and I am not arguing that we will ever run large trucks over a 1500-mile route, but it is indicated that things can be done with a large pneumatic-tired truck that cannot be done with a solid-tired truck. We tried sending solid-tired trucks to carry some cargoes to Philadelphia from Akron. We wanted to get a comparison with our pneumatic-tired truck units. The driver made one trip and quit. We could not have hired him to make another trip at any price.

S. B. LAMBERT:—What troubles have been experienced with air-pumps, as to oiling, dirt and heating of the pump? One that pumps to a pressure of 100 lb. per sq. in. is apt to get hot. Has anyone had trouble in getting the right pressure for large tires?

MR. SCOTT:—In a general way, the trouble with pumps has been that they get hot and will not function. The bearing burns out. The pump manufacturers have had to use the very greatest skill in making an air-cooled pump that is fool-proof. Naturally, the air-pump receives very little attention. The pump manufacturers have changed their models repeatedly and now have something that they consider satisfactory.

Another problem is how the pump should be attached to the car. This has been worked out by having a connection which is standardized to a greater or less extent on the transmission.

CENSUS OF ELECTRIC LIGHT AND POWER CENTRAL STATIONS

THE printed report of the Census Bureau on electric light and power central stations for 1917 was issued during September. The first complete census of electric light and power stations was taken in 1902 and comparative statistics are confined to that year and to the three quinquennial periods following. The same general form of schedule was used in each of these census.

The report which has just been issued covers the general development of electric light and power central stations of both the steam and the hydroelectric type. The general record of primary power equipment with special attention to generating, line and substation equipment is presented. The output and the disposal of current are classified. Very comprehensive financial statistics are given with special comparative financial and operating summaries of selected groups of electric stations. Interesting data on employes, salaries and wages are also given.

Special features of this report are tabulations prepared with the idea of making it possible to study the aspects of the efficiency of commercial and municipal plants. A selection and grouping of plants generating current by steam, water, gas and oil have been made to show the relative financial and physical efficiency of operation. A comparison is also made of several of the more important plants which purchase current with those that generate their own. Typical plants which generate no current have been grouped according to the amount of their output, so that the relative efficiency of size and ownership can be studied.

NATIONAL TRANSPORTATION

THE people of the United States are taking the first steps toward the final goal of a unified national transportation system that will include waterways, railroads and highways, each developed according to the country's traffic needs, and all coordinated as to make their joint use not only possible but regular and automatic. Eventually the shippers located upon hard surface highways will be able to start their shipments by securing the services of common carriers operating motor trucks and having authority to issue receipts or through bills of lading for the transportation of the products by connecting rail or water carriers through to their destination. The ideal of through routes and through services by automobile, rail and water lines will eventually be realized. When this has been accomplished, industry can be carried on advantageously in all parts of the country and can develop freely, unhampered by transportation limitations. This ideal cannot be attained in a day, but the steps that may now be taken to connect railroads and waterways and to increase their joint use will bring the country appreciably nearer the time when all people and all industries will be adequately served by a complete transportation system.—E. R. Johnson in *Transportation World*.

DAY

Gripper and Side Guide

Four-Wheel-Drive vs. Caterpillar Tractor

By E. R. GREER[1]

MINNEAPOLIS SECTION PAPER — *Illustrated with* PHOTOGRAPHS

It is generally conceded that the province of the four-wheel drive is between the place where the two-wheel drive leaves off, and where the caterpillar begins. Rear-drive trucks and tractors are popularly accepted as being all that is desired as long as working conditions are not bad enough to prevent their operation. Caterpillars are admitted to be able to go where it is so soft that no other vehicle can navigate, but they are considered as too slow, awkward and expensive to use where the work can be done with wheel equipped machines. Where does the four-wheel drive come in? Has it a province wherein it is better than other types?

Economy is the answer. The machine which accomplishes the work at the lowest cost is the type that should and will be used most. Range of operation is a very important factor in figuring economy, for when we say economy we must figure in every possible item of cost. Probability of delays, inability to perform, awkwardness, waste of energy, limitations in speed and traction and waste due to having an unused excess of power and strength; these are all factors that determine the range of operation and affect the economy.

A FOUR-WHEEL-DRIVE TRUCK IN SOME HEAVY GOING

THE EXPERIENCE OF THE ARMY

The experience of the Army in motor transport work has clarified many points in a very decisive way. All types of drive have received recognition and today the standardized motor transport equipment attached to an Army division now calls for 54 four-wheel-drive trucks. Of course, some of the standardized units were accepted because they were available and not because they were ideal. No track-laying type machines are called for, but the Ordnance field service operates the caterpillars and tanks, so it is interesting to note that the tanks were hauled on trailers pulled by four-wheel-drive trucks when the Army wanted them moved any great distance.

BREAKING A ROAD WITH A SCRAPER ATTACHED TO THE FRONT

A four-wheel-drive truck or military tractor was designed as an ideal machine for Army use, but though each item in detail embodies improvements over existing four-wheel drives, the machine as a whole has failed to perform enough better than the commercial type to warrant its adoption. Its tractive ability is very high and it is economical as regards mechanical efficiency. The extra wide range of operation attempted was perhaps a little over done. One of the men who most thoroughly understands this machine states: "There is no problem in the four-wheel-drive construction that is not satisfactorily solved in the two-wheel-drive type." That is, there is nothing freakish about a four-wheel drive.

Caterpillar tracks were used by the Army in many

HAULING THE CALIFORNIA BEET CROP IN A PLOWED FIELD

[1]M.S.A.E.—Vice-president and engineer, Motor Transport Co., Minneapolis.

ways. Some balloon corps' four-wheel-drive trucks were equipped with the caterpillar drives on the rear axles, the front wheels being driven in the usual way. This combined four-wheel-drive-caterpillar could get over some very soft ground, but a commercial adaptation of this kind would not likely be very economical. Even Ford ambulances were tried out equipped with caterpillar tracks.

One of the biggest problems in tractor design is to gain sufficient adherence to the ground. Caterpillar and four-wheel drives have been receiving much attention. *Automotive Industries*, mentioning four-wheel drives asks, "How great is this advantage and at what price must it be bought?" It is suggested that 90 per cent of the weight of a rear-drive machine is on the rear wheels when it pulls a full load, and that, therefore, driving the front wheels can only result in a gain of 10 per cent additional traction.

Making a four-wheel drive means much more than just driving the front wheels. It means, above everything else, balancing the load and distributing the power, so that each wheel drives equally with the others. This fundamental requirement of balance has been overlooked in the case of nearly every four-wheel-drive tractor, but has been carefully considered in four-wheel-drive trucks.

The Four-Wheel Drive Applied to Tractors

The advantage of a proper four-wheel-drive application to a farm tractor is very great. On side hills a slight turn of the front wheel will hold the tractor to a straight course instead of causing a bucking action. One condition met with on the farm land is the ridges that are made by a cultivator or lister. To plow such land, crossing the ridges, causes a rear-drive tractor to lose much power and sometimes dig itself into the ditch between ridges. A four-wheel drive would cross this ground almost as easily as though it were level, if the wheelbase was 63, 105, 147 in. or near enough so that one set of wheels could be on a ridge when the other wheels were in the rut. In crossing any kind of a ditch there is an enormous advantage in a four-wheel drive, for the front wheels will always climb, even when a wall higher than the wheels themselves is encountered. It can readily be seen that good performance can be secured from wheels much smaller in diameter than are required for a rear-drive tractor, though, of course, still greater efficiency will result from the use of larger diameter wheels in any case. On side hills it is not easy to handle any kind of a tractor. A caterpillar has to be pointed uphill and actually slides along sideways to plow a straight furrow, and the control is very difficult. When the steering wheels are also the driving wheels the machine goes in the direction in which the wheels are turned, making the action always positive. There is no trick to handling a four-wheel drive as it is exactly the same as handling a rear drive as far as the operator is concerned.

A Four-Wheel-Drive Tractor Climbing a Sandy Hill

The matter of clearance is important and this is much more easy to secure with a wheel than with a caterpillar. Parts can be protected from dirt more easily in a four-wheel-drive construction than in a caterpillar.

As to mechanical efficiency there can be no question but that the wheels on anti-friction bearings, connected to the engine by not over three gear reductions, are much more efficient than a train of links and joints, working in the dirt and roughly driven by a cog wheel, which itself is generally connected to the engine by three or four gear reductions. On the other hand the loss in power due to slippage and to rolling resistance of the wheels may be enough less in the case of the caterpillar to more than overcome the difference in mechanical efficiency if the ground is very soft.

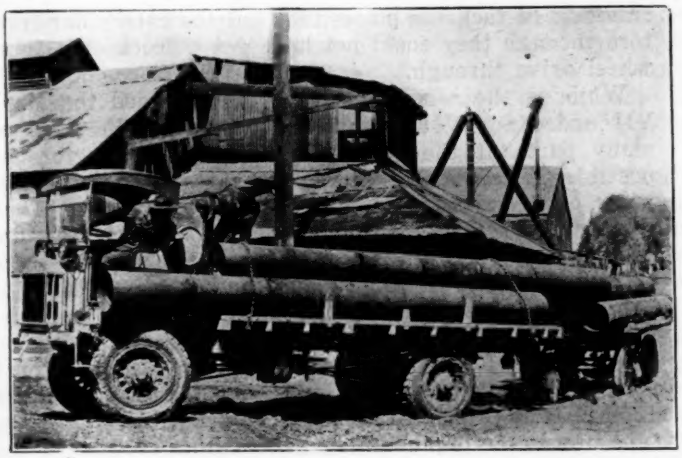
Initial and Maintenance Costs

Considering first cost or selling price, 15 per cent is about the additional cost to build a four-wheel-drive truck as compared with a rear drive of the same capacity and quality. The difference would not be as much in the case of a tractor because smaller diameter wheels can be used with a correspondingly smaller gear reduction, both of which will result in lowering the cost. There seem to be no reliable figures that can be found to show how much more it costs to build a caterpillar. It is likely that the caterpillar first cost will be considerably more than 15 per cent above four-wheel-drive costs.

It is maintenance cost that must be chiefly considered, and any extra first cost must be made up in the operation of the machine. Four-wheel-drive trucks and tractors have generally been used for extremely bad rough going and have not been accorded credit for their performance but have been blamed for high maintenance cost. On the same work with rear drives the four-wheel-drive should always be more economical.

The maintenance cost of a caterpillar however is very high even where wheel machines could be used. A well-known Motor Transport Corps engineer, referring to track-laying cargo-carrying trucks, says: "One drawback to its use at present is the fact that over hard roads the wear and tear on the vehicle is greatly exaggerated and the maintenance problem is severe." There can hardly be any question that the use of caterpillar construction is justifiable only where the ground is so soft that wheels sink in or slip excessively.

Four-wheel-drive construction can be justified for a wider range of conditions than any other type, because it can very nearly outpull a caterpillar in soft ground and can show better economy than a rear drive on hard ground. One proof of four-wheel-drive efficiency can be found by comparing the tire mileage of rear-drive and four-wheel-drive trucks. First of all the four-wheel-drive does not require as great a total tire width. Four tires 6 in. wide would be used on a four-wheel-drive as against two dual 5 in. and two single 5 in. on a rear-drive, the diameters being 24 and 30 in. respectively. The tire mileage however will be found to be at least twice as great on the four-wheel drive. A motorcycle is especially hard on tires because it is only a one-wheel drive. It



A Four-Wheel-Drive Truck and a Trailer in Service for Pipe Hauling

wastes power to wear out tires. Tire wear is not a factor in tractor operation but wheel slippage is, and it means lost power. The wheel slippage on a four-wheel drive will surely be much less than half of the slippage on a rear drive of equally good design and of the same power and total weight on the traction wheels.

A tractor should be as simple as possible and the single-drive wheel offers the greatest advantage when viewed from this angle. The caterpillar then is the most complicated. How much complication is necessary to accomplish the work to be done? Or rather how much is desirable? It depends largely on the knowledge and ability of the operator. Education is needed to make any kind of a machine successful, and except for sales resistance complication is not so serious as it might seem at first thought.

Lighter weight is possible with four-wheel-drive construction than with either caterpillar or rear drive. There is no weight wasted in parts that do not serve as part of the driving mechanism, and because of the division of work between four wheels instead of two, the parts can be made very much lighter. Spring mounting can be easily used and the unsprung weight kept comparatively light.

There are, of course, many widely different ways of making a four-wheel-drive. The new cultivator that the General Motors Truck Co. is building is an unusual application, but though the four wheels are driven, it is not the type of drive that has been considered in the points mentioned. There will no doubt be very many new machines brought out with a four-wheel drive; some will fail and some will surely succeed and occupy an important place in the tractor and truck field. It is a progressive step because it is a step toward greater economy.

The Discussion

E. F. Norelius:—I have been greatly interested in the caterpillar tractor as I have been with it for the past ten years. One point which impressed me was the statement that the caterpillar is hard to control; still Mr. Greer goes on to say that a four-wheel drive is easy to control because he steers the driving wheel. Surely the caterpillar tractors must be easy to control because that is the way we steer them, by the driving wheels. I believe any man with experience will admit that the caterpillar is one of the easiest tractors to control and that you can plow a straighter furrow with that type of tractor than you can with other types, especially those which are driven entirely through the differentials, because we have the positive drive and a positive control for each wheel.

R. S. Kinkead:—When I was over in France, I saw a four-wheel-drive tractor take a 36,000-lb. gun and go down the road with it at 25 or 30 m.p.h., and I realized that it was pulling more than I had any idea that a tractor could pull. We are greatly interested in the possibilities of the four-wheel drive in connection with road work because the Government is appropriating a large amount of money for road building. One or two persons in the city working on roadmaking machinery have asked me about the four-wheel drive and its possibilities in connection with this work.

What should be the diameter of the wheels for a machine which could be used for going out into the country and doing road work, the size of the engine being about the same as the three or four-plow type? What is the possible turning radius that could be developed with a machine of this type?

In regular tractors with the two-wheel drive at the rear the reaction of the tractor load goes directly into the body of the tractor through the driving pinion. With the four-wheel drive taking half of the load off the rear end and putting it to the front, is it possible to spring-mount the entire bed, transmission and body so that with the divided stresses this difficulty does not occur?

In Mr. Greer's presentation of the four-wheel drive they have torque-arms to take care of the reaction of the wheel. I would like to know about the torque-arm versus the spring. I do not know whether they call it the Hotchkiss drive or not, but I have watched with much interest the effect on four-wheel drives that carry this torque by the spring, and they show wear on the shackle due to the reaction of the load. There is an element there which some people handle by carrying a torque-arm and a couple of springs in front and, by the way, nearly all of those springs break.

The only people that I know of who made much of a move toward a high tractor speed were the builder of the Nilson tractor and Henry Ford, who got up a relatively high speed, but due to this element of unsprung weight they had to drop back again. Unsprung weight is the element that comes into the proposition. Even though he builds a machine going down the road at 8 or 10 m.p.h. the maintenance cost does become prohibitive except with the Government. It certainly does with the farmer. With the four-wheel drive it would be all balanced except the front wheels.

E. R. Greer:—As to wheel diameter, a tractor which would be designed for a four-plow proposition, in almost any kind of going would get sufficient traction to handle four plows if it was equipped with 42-in. wheels. I do not think there would be any difficulty due to the fact that the wheels were too small. It is possible to use 48-in. wheels which might be more efficient, but for mechanical reasons of construction, cost, etc., it is important to keep the diameter small. The wheels should be equipped with a gridiron type of lug. I have seen some comparative tests made with that type of lug as against ordinary spikes and it makes a great difference. This particular type will actually drive the front wheels up a straight wall.

Mr. Kinkead:—Is there a differential between the front and rear wheels?

Mr. Greer:—There is no differential between them on the tractor. The Four-Wheel-Drive truck is built with a center differential and there are some reasons in favor of it, but I would not say it is necessary in a tractor. In a tractor wheel slippage occurs to some extent, probably as high as 3 per cent most of the time, and that differ-

ence in slippage would probably be enough to equalize the action of the wheels.

Constructional details make a big difference in the turning radius. Universal-joints can be used at angles up to 30 deg. if the joint is built right. The four-wheel-drive truck turns in 25¼ ft. A tractor built at Clintonville steers on all four wheels or only the front wheels by taking out a few bolts. With the four-wheel steer I understand it can turn around in a 20-ft. radius. Whether we should have a two-wheel or four-wheel steer is a question. If we tried to plow with a four-wheel steer and hitch our plow at any point other than the neutral point, which would be the center of the tractor, we would have the sorriest looking furrow we ever attempted. It is possible, however, to pull the plows from the center and if we plow from there that difficulty will be overcome.

To my mind a four-wheel-drive construction is the only one that offers the opportunity to spring-mount a tractor properly. Mr. Kinkead referred to the four-wheel drive as having torque-arms. We have some trucks out without those arms, using a Hotchkiss drive. In towing heavy loads, it is surprising how much easier the action is if we omit the torque-arm and have the entire action through the springs. A very interesting thing has developed. Where we were able to break the springs using a torque-arm, when we left it off we could not break a spring. It allows the axles greater freedom, but it works the universal-joints harder when the drive is through the springs. We have more angularity to take care of through the action of the universal-joint where the spring action absorbs the jerks. When we make our spring mounting for the tractor we do not consider only the weight of the tractor. We have a drawbar and must spring-mount it, that is, we have to take care of the spring action on the drawbar. It is also necessary to have springs on the axles so that the torsion gives the axles considerable movement. The wearing of the shackles or anything of that kind need not be considered as any great difficulty. Four-wheel-drive construction does not use shackles on the front springs and the rear springs are shackled on the rear end only. The front end is a regular Hotchkiss drive action.

A. R. Sandt:—On the four-wheel-drive tractor I worked out several years ago, I had wheels 40 in. in diameter with a 10-in face. They were spring-mounted all around, with coil instead of elliptical springs, carrying the drive through the torsion rods. We found in running tests on this machine that the way it performed in going through soft places and over sandy hills, where we had another standard two-wheel-drive machine that was getting stuck, was remarkable. The two-wheel-drive machine had wheels 56 in. in diameter with a 10-in. face pulling three plows. It ran into a swamp and the wheels buried themselves to the frame; there was no way of getting in or out. We ran the four-wheel-drive machine alongside the two-wheel drive without sinking in. Then we drove in front, pulled the latter out and went along. We had the same experience a little later on a sandy hill, where the two-wheel-drive machine buried itself and we drove around in front and pulled it out.

The four-wheel-drive machine had a Buda 4¼ by 5½-in. engine and was pulling four 14-in. plows in sod 6 or 8 in. deep. We were running at a speed of only 1¾ to 2 m.p.h. trying to overload the machine as the farmers do. The machine was really designed to pull only three plows. I had experience with caterpillar tractors in the Army. While we were running tests at the Rock Island Arsenal, they did not put the four-wheel-drive trucks and tractors through the same tests that they did the caterpillar tractor. In fact, the places they put the caterpillar tractors through they could not have got a truck or a four-wheel drive through.

While in the service at Detroit I designed the Mark VII and Mark VIII caterpillar caissons. We used as many parts of the 5 and 10-ton artillery tractors as possible. These machines were to carry their respective loads of 6 and 10 tons at the rate of 7 m.p.h. They would perform satisfactorily in road work if the upkeep was not so high, for it was possible to turn them around in their own length with the load.

I do not believe that the turning radius of the four-wheel drive can be made short enough for working on some roads. I was down near Wabasha, Minn., a short time ago and they were making some roads and using a 125-hp. Holt caterpillar. They could not use any other type of tractor because they had to turn around on the hillside and practically in their own tracks.

I believe there is a market for the four-wheel-drive tractors if the price of tractors is brought up much higher than it is, because to get a light machine better materials will have to be used. Otherwise they will not compete with the two-wheel-drive machine for pulling the same number of plows.

A. F. Moyer:—Mr. Greer has said that the place for the caterpillar machine is on very soft ground. From experience and experiments on rolling resistance I could see that this was a good argument. In very soft ground the caterpillar machine would be superior in exerting much less unit pressure on the ground and making less depression for the displacement of soil required to support the weight. In comparison with the four-wheel-drive tractor or truck has Mr. Greer observed any data which would tend to show any relation between the rolling resistance of a round wheel when it is merely a load-carrying wheel and when it is a driving wheel?

Mr. Greer:—We have not been able to do that because it is impossible to put a load on a truck which will be all the engine can pull. A 3-ton truck may be able to support 10 tons, but it can easily pull 40 or 50 tons on a trailer. Because you could not make the truck stand up with even 10 tons, you cannot get a comparative figure as to the efficiency of the traction for loads carried or pulled. There is no way you can load those wheels so they will require all the available power, considering, of course, hard level road conditions.

B. S. Pfeiffer:—Where did Mr. Greer get his data on the organization of an Army division?

Mr. Greer:—It was taken out of General Drake's report which gives the organization of the Army at the present time and is a regular printed Army organization pamphlet.

Mr. Pfeiffer:—That was not just exactly as they had it during the war.

Mr. Greer:—No; during the war the Nash Quad was used. At present the Four-Wheel-Drive is the only standard four-wheel drive.

Mr. Pfeiffer:—Yes, but I meant with reference to the other units; have they done away with the other artillery tractors?

Mr. Greer:—In a regular Army division they now specify 54 Four-Wheel-Drive trucks, they have some class B trucks, some of the aviation trucks, Cadillac cars, a long list of Dodge cars and a number of motorcycles.

Mr. Pfeiffer:—Have they discontinued using the caterpillar type of tractors?

Mr. Greer:—The Ordnance Department has the final

word about the caterpillars and tanks, and none of those are regularly assigned to a division. It is up to the Ordnance Department to decide where it will operate them. The Motor Transport Corps uses the trucks, and the tractors would be used when the Ordnance Department decided they were needed.

MR. KINKEAD:—I think Mr. Greer is correct as the division only carries the light material with its equipment. The caterpillar is used in another department and was considered as Army equipment. Divisional equipment does not include as heavy material as Army equipment. The Army is equipped with a caterpillar tractor that takes loads from 14,000 lb. up and probably always will be. Regarding turning radius, could not a four-wheel-drive truck such as Mr. Greer defines probably bring its front wheels to an angle of 40 or 45 deg., and possibly have a differential lock or some other mechanism? Is it then possible to get the four-wheel drive to turn around in its own tracks, by driving the outside wheel?

MR. GREER:—During the turning action in the four-wheel-drive truck, it drives just the same as going straight. There is no slippage, as the action is compensated for. We could make a shorter turn by braking the inside wheel. The 25-ft. radius is less than with some standard rear-drive trucks. I think the difference is almost 15 ft. The only reason we cannot turn any shorter is because there is not sufficient clearance between the front wheels and the springs. The angle of the universal-joint to make that $25\frac{1}{4}$-ft. turn is only 25 deg., so there is no question in my mind but we can go still further with a front-wheel steer, and if we have a four-wheel steer we should be able to turn in half that distance.

There is one thing about this angle of the universal-joint; speed is a very important factor. In a tractor the speed will be slowed up so we can work the joint through a greater angle. In a Four-Wheel-Drive truck the universal-joint is in a live axle and the joint only runs at axle speed. In one make of four-wheel-drive truck it is not, which means that the joint runs about four or five times the wheel speed. It would be more difficult to turn the latter than it would be to turn a wheel driven by a live axle on account of the speed of the joint.

MR. SANDT:—Has Mr. Greer carried on any experiments by placing a differential between the front and the rear axle? When the Ordnance Department changed the Nash Quad over to make a solid axle and only steered with the front wheels a differential was put in at first and after running a 10,000-mile test without using the differential the wear on the tires was so slight that the differential was left out.

MR. GREER:—All our trucks are built with a center differential. It is a very common thing for us to find that when a new driver on the truck gets stuck and locks his center differential to get out, it stays that way until somebody finds out it is locked. The only difference that the operator will notice particularly is the steering of the truck; it will not turn a corner as easily. He never knows the wear and tear there is on the parts because he has that locked and the wear and tear on the tires is comparatively small. In driving over a bump the front wheels go over and the rear wheels ride straight. If there is not some differential action to compensate for it, the front wheels are bucking the rear pair and a strain will be produced in all the driving mechanism throughout the machine. The tires will show such a marked difference in driving with a differential that it will pay to put one in.

It is different with a tractor because there we are driving all the time practically with a wheel slippage and I think this is always enough to compensate for the difference between the rear and front drive so we will not get the bucking action.

MR. PFEIFFER:—Do you use a locking differential in the axle?

MR. GREER:—No. The object in a four-wheel-drive is to equalize the power to each wheel and it requires an absolutely free differential action to accomplish that perfectly. We put a hand lock on the center differential and with that locked we must get one wheel on both axles to slip before we become stuck. It is almost impossible to get into such a position that at least the two wheels on one axle would not be squarely on a footing. We can get through any place that a man ought to try to get through, without a self-locking differential.

If we put a self-locking device into a differential we spoil our efficiency, but that is not the only reason. To put a locking differential in a vehicle requires a very big differential to get large enough surfaces because any locking differential is a friction construction; we must have an oversize differential to incorporate the locking device. The four-wheel drive because it is a four-wheel drive seems to be subject to abuses, and we have to guard against them as far as we can. We have fought the locking differential, although we have tried every type of locking differential ever brought out and have absolutely ruined every one.

MR. RICHARDSON:—In an Army camp I had considerable experience with the Four-Wheel-Drive trucks operating in kaolin, which is slippery stuff to get into. It was almost impossible to get into any position where the center differential would not get me out; I never saw any in which we could not get out with three wheels by locking the center differential.

MR. SANDT:—Is anybody present who is acquainted with the details of the four-wheel-drive tractor that has a chain drive from the center to the rear and also to the front. I have heard that the rear sprocket and the chains have been giving a large amount of trouble and the front sprockets and chains show no wear. The four-wheel-drive tractor I designed and built a number of years ago was a gear-driven machine throughout and I duplicated the driving parts at the front and rear. Anybody would understand the difference between the two units and a man who repaired one could repair the other. On the chain-driven machine I mentioned there was undoubtedly no means for equalizing the chain tension or the weight and the drawbar was not properly placed.

MR. GREER:—I have never seen a four-wheel-drive tractor where the balance of weight was anywhere near where it should be. The builders seem to be absolutely lost when it comes to getting the weight balanced so there is an equal weight on each wheel when the machine is pulling, and if the wear on the front and the rear is unequal I believe that weight is unbalanced.

CHAIRMAN J. L. MOWRY:—I had some experience with a four-wheel-drive tractor of the type Mr. Sandt has mentioned and it had that same peculiarity. The rear chain very soon wore and stretched to the point where it would climb; so soon, in fact, that before this tractor could be put through any test whatever the ordinary two-wheel rear-drive machine could pull it anywhere. We could give the four-wheel drive a start and the other machine would stop it and pull it backward. It had the same trouble, unbalance of weight, and the front wheels were almost valueless. The total load was taken by the chain to the rear wheels and it could not stand it since it was not designed to.

Plywood and Its Uses in Automobile Construction

By ARMIN ELMENDORF[1] CLEVELAND SECTION PAPER

SINCE the publication of this paper in the May issue of THE JOURNAL, a written discussion has been received from Lawrence Ottinger. This discussion and the author's reply are given below. For the convenience of the members a brief abstract of the paper precedes the discussion.

ABSTRACT

FOR many years plywood has been used for such automobile parts as roofs and dash and instrument boards, but it was not until the closing of the European war that the extent to which this material was used in automobile construction greatly increased. The sudden requirement of airplanes created a large demand for plywood which would withstand the severest weather conditions. Glues were perfected that enabled plywood to withstand 8 hr. of boiling or 10 days of soaking in water without separation of the plies. Plywood as an engineering material is next discussed. It is then compared in considerable detail with ordinary boards and also with metals and pulp boards, statistics and illustrations being given. The molding of plywood is considered with especial reference to employing plywood for surfaces having compound curvatures, and the limiting factors in the use of plywood for this purpose are mentioned.

THE DISCUSSION

LAWRENCE OTTINGER: — Mr. Elmendorf correctly points out the limitations of curvature in molding plywood, but ends his paper with the statement that the molding of plywood to compound curvatures is limited and that "such curvatures as those in the cowling of an automobile cannot be made of plywood." This is correct, but it applies only to the molding of plywood in its finished form; after it has been glued, put under pressure, dried in flat sheets and thereafter steamed or boiled before being reformed. He is not correct, however, in stating that such curvatures cannot be made of plywood if the plywood is formed while the glue lines are still wet. Several body builders are making cowls of plywood, but they apply the glue to the veneers and immediately place them under pressure, the slippage on the glue lines permitting far greater curvature, with practically no limitations. It is possible to mold a complete hemisphere in this way. A thin sheet of veneer can be bent into almost any shape. If the molding is done while the glue lines are still wet, the "upset," or compression, applies to the inner surface of each sheet of veneer. But in rebending plywood that has been completed, the stresses are much the same as would occur in a piece of lumber of the same thickness, because the plies cannot move in relation to each other. This matter is important because body builders are much more likely to make their own plywood than to buy manufactured plywood, for several reasons. One of these is that the same mold which would be used in molding a piece of plywood can also be used to manufacture plywood, provided a cold waterproof glue is used.

ARMIN ELMENDORF:—The statements referred to relate entirely to the molding of plywood that has first been glued into the form of a flat sheet and to the manufacture of cowling by this method. There are, no doubt, certain automobiles in which the cowling is made of plywood, and it was for this reason that my statement was qualified to "extreme warped surfaces must continue to be made of steel or aluminum." The cowling of most automobiles has rather severe compound curvatures. I am aware that "slippage on the glue lines permits far greater curvature." I have made tests of this method of molding and, in spite of various ways of conditioning the veneer prior to gluing, found that the veneer would check or split in the faces. To avoid this, I found it necessary to cut the individual strips to certain forms; this I considered impractical. The checks that develop can be filled with the usual putties or pastes but, as plywood, the job would not be countenanced by any scrutinizing purchaser.

Regarding the molding of a complete hemisphere of plywood, I infer that this is done by taking several sheets of veneer of the full size and gluing them together in a form, but I have found that the limitations for molding in this manner are so great that I abandoned all thought of molding in compound curves by pressing the separate sheets of veneer together and allowing the glue to set in the mold. Checks or splits in the face veneer are invariably obtained if the compound curves are appreciable.

MR. OTTINGER:—The paper did not clearly convey to me that it referred entirely to the molding of plywood that had first been formed into flat sheets. This, combined with the statement that extreme warped surfaces must continue to be made of steel or aluminum, indicated a limitation to the use of plywood that does not exist.

I feel that plywood will be used almost exclusively for automobile body building, the body builder buying large panels in sheets. Such parts of the body as have compound and extreme curvatures will be laid up wet. Several body builders are using this method at present.

As to molding a complete hemisphere, I have made several of these in various ways. They have been practically free from surface checks. I overcame these by using thin veneers of high density in one case, but my most successful result was accomplished by cutting and taping the veneers over a curved surface and dipping the center veneers into the glue, instead of putting it through a spreader, as in the case of a flat panel.

[1]Consulting engineer, Haskelite Mfg. Corporation, Chicago.

Relation of Rib Spacing to Stress in Wing Planes[1]

THE change of spacing between ribs in a wing plane may entail, (a) change of air pressure, both in distribution and amount, and (b) change of fiber stress in the fabric and the ribs, unless they be so altered in dimensions as to keep their stresses constant. The aerodynamic effect just stated should be studied in the wind tunnel, or still better in full-scale flight, with pressure collectors at many points on a median section of the wing. The stress relations to the fabric and the rib will be considered in some detail here.

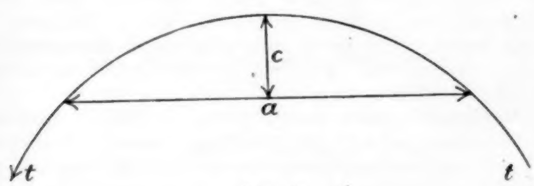


FIG. 1

FIBER STRESS IN FABRIC AND RIB

It can be shown that the tensile stress t per unit width in the fabric of a wing plane, at a point where the resultant air pressure on it is p, is approximately $t = pa^2/8c$, a being the distance between the ribs, and c the depth of bulge of the fabric midway between ribs at the locality in question. Hence keeping the air pressure p and the shape of bulge or c/a constant, the lineal tension t varies directly as a. If then the fabric thickness be directly as a, the fiber unit stress is the same for all practical rib spacings. And conversely if the fiber unit stress remain constant, with varying rib distances, the bulge shape must remain constant, assuming the initial tautness the same in all cases.

To prove the truth of the formula given, if p, a, c, denote, as before, the unit resultant air pressure, rib spacing, and depth of bulge; and if r be the radius of curvature of the bulging fabric, assumed to be circular, as Fig. 1, the following relations obviously obtain:

$$t = pr,$$
$$a^2 = 4c\ (2r - c),$$
$$\therefore t = \frac{pa^2}{8c}\left(1 \div 44 = \frac{c^2}{a^2}\right)$$

The first of these comes from equating the up lift of the air to the down pull of the tension; the second from equating the square of the chord to four times the product of the segments of a normal diameter. The derived equation shows that if $c/a = 1/20$, $t = pa^2/8c$, accurately to 1 per cent. In taut fabrics c/a may equal 1/20, or thereabouts, under full load.

By well-known mechanics, the unit stress in a simple beam, with either a concentrated or a uniform load, is of the form

$$S = A\ \frac{WL}{bd^2}$$

in which W is the load, L the length, b the width and d the depth. If the wing plane and its ribs remain geometrically similar, b and L increase directly as d, and W as d^2, since W varies as the area. The stress therefore takes the form

$$S = K\ \frac{d^2 . d}{d . d^2} = \text{constant}$$

Considering therefore the wing plane simply as a static structure, and ignoring the question of aerodynamic efficiency, it appears that the unit stress in the rib and fabric will remain constant for a constant value of p if the linear dimensions of both rib and fabric be increased alike, if wing and fabric remain geometrically similar. Since the bulge as well as the structural dimensions remains geometrically similar, the whole distended plane remains so, and hence should have the same pressure distribution and efficiency. If therefore the Burgess rule of making the rib spacing always one-fifth of the chord of the plane be valid for any one plane, it must be valid for all others that are mechanically similar in structure and covering.

STRESS-STRAIN RELATIONS IN WING PLANE FABRIC

To determine whether a given fabric is suitable for a given rib spacing a stress-strain diagram is made for samples of the fabric. The relation is roughly

$$t = k\,e,$$

in which k is a constant, and e is the true strain, that is the stretch of a given length of sample divided by the unstretched length. If in the wing plane, a be the rib dis-

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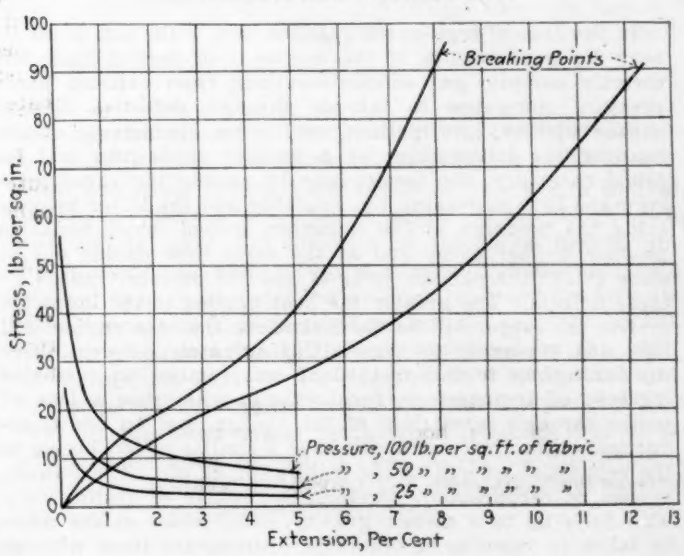

FIG. 2

[1] From Technical Note No. 5 of the National Advisory Committee for Aeronautics, Washington.

CARBURETION OF HEAVY FUELS

AN actual vapor is of value for combustion purposes mainly because intimacy of mixture and of molecular contact is assured thereby, rather than because there is any special fetish in the mere fact of the fuel being in the form of a vapor. On the contrary, a finely divided spray is known, both in practice and in theory, to be more efficient for high power purposes than a dry vapor. The reasons for this apparently contradictory state of affairs are twofold; first, fuel in the form of a spray takes up less room than when completely vaporized, and therefore leaves more space for the inspiration of oxygen, and as the power of an engine depends upon the weight of oxygen burnt per unit of capacity the advantage of increasing its volume will be obvious and, second, the presence of a finely divided wet spray tends, during its subsequent vaporization, toward a lowering of the flame temperature, owing to its latent heat, and it is now known that a low flame temperature is one of the prime essentials in efficiency. It must be emphasized, however, that these conditions only obtain during periods of high output when the induction velocity and the rate of charge turbulence are very high. They are cited here only to show that the dominant requirement is an extreme degree of mixture intimacy, whether produced by fine disintegration or by direct vaporization.

Unfortunately the conditions appertaining to engines of high output, which are designed to run at high speed and reasonably constant loads, are very different from those with which we are concerned in motor-car practice, where easy starting, idling at a minimum speed, flexibility at low throttle positions and similar qualifications are of paramount importance. In these circumstances, when slow induction velocities and reduced rates of charge whirling are greatly in evidence, the problem of achieving homogeneity, or intimacy of the mixture, by simple fuel disintegration becomes a weighty matter, and, so far as can be seen at present, cannot be solved without the aid of heat.

The velocity or capacity for evaporation of a fuel is simply a relative term and assumes normal temperatures and pressures; it varies directly with the former and inversely with the latter. A boiling liquid to which pressure is suddenly applied will immediately cease to boil even though its heat is maintained, and for the same reason pressure applied to a vapor will have the result of condensing and depositing it unless the temperature is simultaneously increased to counterbalance the raising of the boiling point produced by this action.

Why Heavy Fuel Needs Heat

In the case of high-grade gasoline very little heat is necessary for good results, if the engine is in perfect tune, but directly periodic gas shocks resulting from exhaust back-pressure commence to intrude through defective timing, choked silencer, late ignition, etc., either an increase of the heat or the introduction of a smaller choke-tube will be found necessary; the former acts by raising the vapor pressure and thus increasing the volatility and the latter by lowering the pressure in the induction system which tends to produce a finer spray and at the same time damps out to some extent the periodic jerks of positive pressure caused by these defects. The greater the heat applied to the induction system the larger will be the choke-tube that the engine will take, and, of course, vice versa. Unfortunately, however, there are limitations to this method of compromise; an excessive increase of temperature, for instance, will cause a loss of power through rarefaction of the charge, and an undue reduction of the choke area will have a similar effect, owing to the restriction offered to the inspiration of air. The present system of carburetion, therefore, is capable of dealing only with fuels up to a certain gravity, after which means must be taken to vaporize or otherwise disintegrate them without either undue heat or choke restriction. The question that concerns us for the moment is how to deal with those fuels which are within the capacity of the modern carbureter if suitably modified.

As has been previously mentioned, assuming the temporary absence of heat, the prime requirements are the production of a finely divided spray and the capacity of the engine to keep this spray in suspension during its passage up the induction tract.

The Best Type of Engine

The type of engine which lends itself best to these conditions is one with (*a*) a short induction system, that is, short in respect of the distance from the carbureter to the combustion head, (*b*) of the smallest possible diameter consistent with the avoidance of undue volumetric restriction at high speeds, (*c*) a perfectly tight tract, (*d*) very good compression, and (*e*) the spark-plugs placed well in the track of the incoming gases. The short inlet pipe is in most modern engines an accomplished fact, but in many cases the diameters can stand reduction.

The reasons for these requirements are fairly obvious; the sooner the spray gets to the combustion head the less chance it has to deposit, and a short pipe of small diameter is clearly the best way to hasten its passage. Then comes the desirability of a gas-tight induction system and perfect compression. The objects of these are twofold; (*a*) the maintaining of the highest possible vacuum, and (*b*) of preventing the already "thin" mixture from being diluted with air.

Most people are careful about their inlet pipe joints, but very few give a thought to the inlet valve-stems and it is here that most of the leakage occurs. There are several devices on the market which seal the contact between the valve-stem and its guide by compressible washers. It is suggested, however, that in view of troubles to come it would be well for manufacturers to give this part more serious attention and incorporate a method for automatic correction of wear at this most important part instead of leaving it to accessory makers to remedy the deficiency.

As regards compression, one is apt to forget that where compression can leak out air can leak in. Loss of compression in a minor degree is of little importance in starting, but the subsequent inward leakage is of considerable importance.

While there is no doubt as to the importance of the spark-plugs being in the path of the incoming charge, it is frequently very difficult to estimate the precise direction that the charge will take on entering the cylinder at a low velocity. Plugs of varying design, therefore, in respect of reach, protrusion of the points, etc., will often give such apparently contradictory results that a decision here is a matter of experiment.

The production of a fine spray at a low mean velocity is the essential requirement; to obtain this a jet must be placed so that it sprays at the point of maximum velocity. In most carbureters this point during starting positions is, of course, at the closing edge of the throttle, but in very few carbureters is the jet placed to the best advantage. In the case of butterfly throttles, for instance, while it is true that in most cases a starting jet is situated exactly at one opening, or, as the case may be, closing, face, no account is taken of the fact that there is another face which is unprovided with a jet. The air, therefore, that enters here is in the nature of a leakage, in that it is not carbureted.

Barrel throttles as a rule have the starting jet placed in the middle of the space between the two opening faces, and, therefore, do not deliver to the best advantage. It is fully appreciated that those designs are for a certain functional purpose and do not indicate short-sightedness on the part of carbureter makers; also that the placing of the jet in the absolutely maximum position is a very difficult mat-

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Optical Determination of Stresses in Airplane Spars

At a recent meeting of the Royal Aeronautical Society, Major A. R. Low of the Royal Aircraft Factory described a series of experiments in which optical methods were employed to determine the stresses on airplane spars. The stresses on these spars are of a somewhat peculiar character. Roughly speaking, each

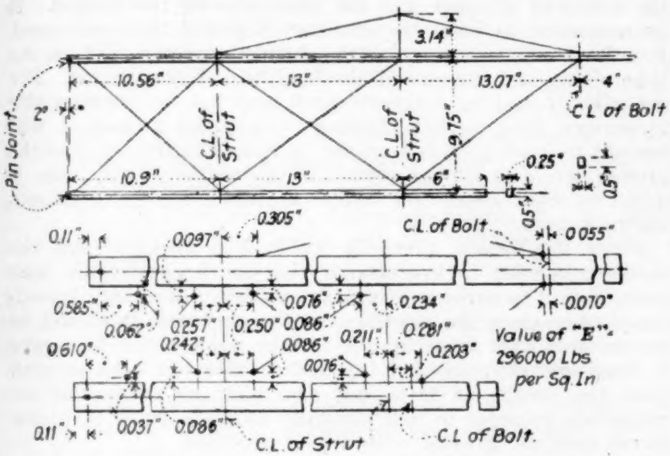

FIG. 1

may be likened to a continuous girder supported at three or four points, and at the same time subjected to a heavy axial stress. Failure may thus occur either through crippling, or by bending, or by a combination of the two. If the axial thrust were very low, the spar might be treated as a simple continuous beam, while if the transverse bending were very small Euler's theory of struts would be applicable. Actually neither alternative is permissible. A complete solution of the problem from the mathematical standpoint was worked out many months ago by the scientific section of the Air Ministry, and the methods of calculation thus derived have been largely adopted by designers. In his paper, Major Low compared the results as computed by this theory with the stresses as determined optically, and found that the discrepancy between the two was sometimes very marked.

The work was carried out at University College, where Professor Coker placed his unique equipment for investigations of this kind at Major Low's disposal. A

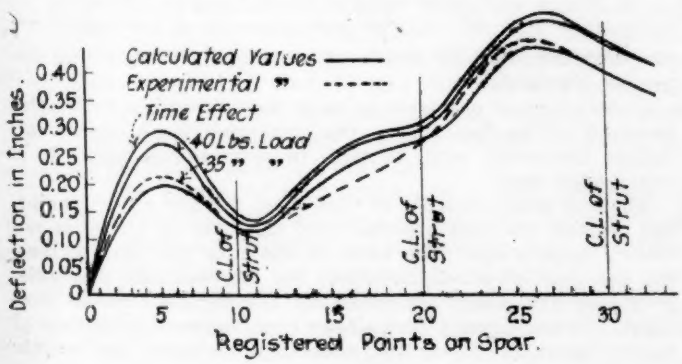

FIG. 2

scale model of a standard pattern of spars and bracing were made, using xylonite for the spars and steel for the struts and bracing wires. The dimensions of the model are given in Fig. 1, while in Figs. 2 and 3 a comparison is made between the deflections and stresses as computed and as determined by the observations. The discrepancies are, it will be seen, very considerable, particularly at the higher loads. In part, this is no doubt due to the fact that in making stress calculations it is always assumed that the deformation of the body under study is so small that its shape is not materially altered by the application of the load. This condition was not satisfied in the experiments, but it is claimed that in actual practice aeroplane spars have occasionally to sustain very large deflections, and that the conditions in these tests approximate accordingly more closely to the actual conditions than do the assumption necessarily made as a basis for calculation. The greatest discrepancy found between calculation and observation was in the position of the points of contrary flexure. In general, the displacement from the computed position was such as to reduce the maximum value of the stress.

When a beam of polarized light is passed through a transparent body under strain, the latter acts like a crystal of Iceland spar. It resolves the incident beam of light into two components, which travel through the

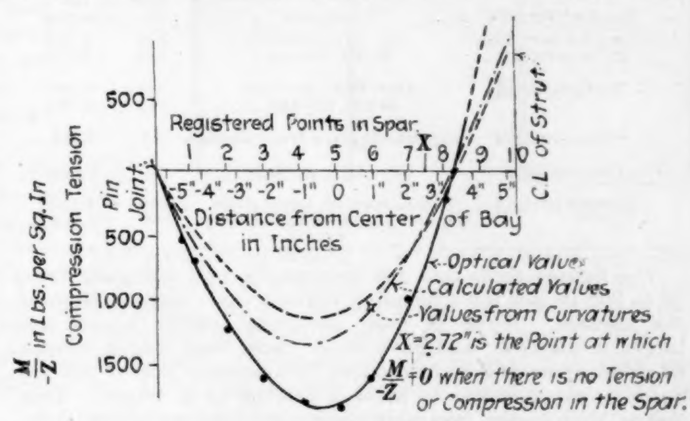

FIG. 3

strained material at different velocities, and hence when on emergence the two components, or parts of them, are again combined interference effects are obtained, giving rise to wonderful displays of color. The tint of the color at any part is a measure of the stress there, and the intensity of this stress is generally determined by finding what load must be applied to a simple tension piece to obtain a corresponding color. In practice the tension piece and the model are traversed by the light in series, the axis of the tension bar being at right angles to the direction of the stress on the model. The load on the tension bar is then adjusted till the color effect is annulled, in which case the stress on the tension piece is equal to that on the corresponding part of the model.—*Engineering* (London).

TRACTOR DRAWBAR-PULL

UNDER the most favorable conditions the power which any given tractor can deliver at the drawbar is limited by the size of the engine, the weight of the tractor and the efficiency of the transmission and is influenced by a number of variable factors which depend upon the conditions under which the machine is operated. This means that with perfect mechanical operation the drawbar-pull available will vary, which explains why a tractor will pull a certain load in one case and sometimes fail with exactly the same load under different conditions. These external factors which have such marked effects on the drawbar-pull available are rate of travel, character of surface, grade, lugs and altitude.

The power generated by a tractor engine is used in a number of ways. Some of it goes to run the fan, pump and other accessories, part is lost in transmission, more is used to move the tractor over the ground, a portion is lost through slippage and lug action, part may be used to climb a grade and the remainder is available at the drawbar for the doing of useful work.

The tractor must propel itself over the ground. On a level surface the amount of power consumed in this operation will depend upon the character of the surface, the weight of the machine, the type of wheel, the lugs and the rate of travel. The smoother and firmer the surface the less the power consumed. So far as is known there are no data available giving the power required to move tractors over the surface, but the problem has been thoroughly studied as relating to wagons, and the results obtained, Table 1, will at least give some idea of the effects produced by variation in the character of the surface.

TABLE 1—PULL IN POUNDS PER TON REQUIRED TO MOVE WAGONS OVER DIFFERENT SURFACES

Kind of Surface	Condition	Pull Per Ton, Lb.	Coefficient of Resistance
Timothy and blue grass meadow	Dry, firm, smooth	120	0.060
	Moist, spongy	170	0.085
Bluegrass sod	Dry, firm, smooth	80	0.040
	Moist, spongy	160	0.080
Wheat stubble	Dry, smooth, free from weeds	111	0.055
Corn stubble	Dry, firm, smooth	160	0.080
Plowed ground	Not harrowed, large clods	200	0.100
	Ground prepared for seeding	160	0.080

The figures show that for wagons the pull will vary from 80 to 200 lb. per ton depending entirely upon the condition of the surface. While in most instances tractor wheels are larger in diameter and have wider faces than wagon wheels, no great error will be introduced by assuming that it will require as much power to move a tractor as a wagon. This means that under favorable conditions such as a dry, firm, smooth bluegrass sod it will require 1.33 hp. to move a 5000-lb. tractor at the rate of 2½ m. p. h., while on plowed ground, not harrowed, it will require 3.33 hp. to move the same tractor at the same rate of travel. Increasing the speed will not, so far as is known, change the pull required to move the tractor, but it will increase the power required. Thus under the same conditions taken above except a rate of travel of 3½ m. p. h., it will require 1.84 and 4.6 hp., respectively.

TABLE 2—POWER REQUIRED TO MOVE A 5000-LB. TRACTOR AND OVERCOME SLIPPAGE AND LUG ACTION

Surface	Pull Required to Move Tractor, lb.	Pull Required to Overcome Slippage and Lug Action, lb.	Power Required at Various Speeds, hp. m.p.h. 2.5	3.0	3.5	4.0
Sod, moist, spongy	200	300	3.34	4.00	4.67	5.32
Sod, firm, smooth	400	400	5.35	6.40	7.47	8.55
Corn stubble, firm, smooth	400	350	5.00	6.00	7.00	8.00
Plowed ground, not harrowed	500	400	6.00	7.20	8.41	9.61

TABLE 3—POWER REQUIRED TO MOVE A 5000-LB. TRACTOR AND A 1000-LB. PLOW UP DIFFERENT GRADES

Grade, per cent	Pull, lb.	Power Required at Various Speeds, hp. m. p. h. 2.5	3.0	3.5	4.0
5	300	2.00	2.40	2.8	3.2
10	600	4.00	4.80	5.6	6.4
15	890	5.92	7.13	8.3	9.5
20	1,180	7.88	9.45	11.0	12.6

In addition to the power actually required to move the tractor a certain amount of energy will be used up through the action of slippage and the lugs entering the ground. It is impossible to state the amount of power thus consumed. It will, of course, vary with the character of the surface, the type of lug and the size of the load behind the tractor. For the sake of making comparisons it will not be unreasonable to assume that on firm footing with a heavy load it will amount to more than is required to move the tractor over the ground, while on plowed ground, with relatively light loads, it might be less. These two factors are often spoken of as rolling resistance.

From the figures given in Table 2 it appears that the power consumed in overcoming this rolling resistance may vary from 3 to perhaps 10 hp. for a 5000-lb. tractor, depending largely upon the condition of the surface. It should be remembered that these figures for the pounds pull necessary to overcome slippage and lug action have not been secured from the results of tests, but are taken as reasonable assumptions in order to indicate what happens when a tractor moves over the ground with a load attached.

Studies on the draft of wagons indicate that the larger the diameter of the wheel and the wider the tire, up to reasonable limits, the less the pull required to move a given load. Undoubtedly the same is true for the tractor, but the height cannot be safely carried to extremes for it would result in giving a center of gravity too high for practical purposes.

The power required to move the tractor and the implement which it is pulling up a grade must be secured at the expense of the maximum power possible to deliver at the drawbar. Generally speaking a pull equal to 1 per cent of the total weight is required for each per cent increase in grade. To be absolutely accurate it will be somewhat more than stated above, but this method of figuring will be sufficiently accurate, especially for slopes not greater than 20 per cent. Table 3 gives the power required to move a tractor weighing 5000 lb. and a plow weighing 1000 lb. up the grades indicated.

TABLE 4—HORSEPOWER AND DRAWBAR PULL AVAILABLE AT VARIOUS RATES OF TRAVEL FOR A 5000-LB. TRACTOR

Rate of Travel, m. p. h.	Power Available at Drawbar, hp.	Drawbar Pull Available, lb.
2.5	16.0	2,400
3.0	15.2	1,900
3.5	14.4	1,540
4.0	13.6	1,280

Unless special provision is made for increasing the initial pressure of the fuel charge the power which an engine can deliver decreases with increase in altitude according to a well-known law.

There is much evidence to show that, for any given tractor, the relation between drawbar-pull and rate of travel is not clearly understood. The facts in the case are that increasing the rate of travel decreases the drawbar-pull available, providing the power generated by the engine remains constant. It has already been shown that increasing the rate of travel increases the power necessary to move the tractor

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Spark-Plug Position

ALTHOUGH the best position for the spark-plug has been settled to a certain extent by practical experience, the most suitable position depends entirely upon individual engine design, and, therefore, the subject is worth careful consideration in view of the many new designs and novel types of engine now being brought out. It is hardly necessary to point out that the position of the plug has a great effect not only upon its effective cooling, but also upon the reliability of its action. It is essential not only for the sparking to be regular and reliable but also for the ignition value of the gas surrounding the electrodes to be uniform.

Obviously, it is of little use to have a good healthy spark when the spark points are surrounded by a quantity of spent gas or when the gas surrounding the electrodes is seriously diluted with spent gases. When it is realized that the spent gases, which, of course, are non-inflammable, amount, sometimes, to more than a quarter of the total charge, the importance of considering the effects of these gases will be well appreciated. As regards the position and action of the spent gases remaining in the cylinder after the exhaust valve has closed, the matter is not so simple as it may seem at first glance.

Distribution of Incoming Charge

At the moment that the inlet valve is about to open, the spent gases occupy only a small part of the combustion-chamber, but during the induction stroke the gases are considerably expanded. In addition to this there is the action of the incoming charge with which to reckon. This depends upon the position of the inlet port, its area, and, to some extent, upon the direction of the gases before entering the port. The velocity of the incoming charge also modifies the effect, according to whether the motion is very rapid or comparatively slow; this depends, of course, upon the engine speed.

The distribution of the incoming charge is due to the action usually known as turbulence, which, as the name implies, is the whirling around of the gases in the cylinder, due to the initial velocity of entry.

This action varies during the induction and compression strokes, because during the former the gases are still being subjected to the suction action and are themselves increasing in quantity, while, during the compression stroke, the gases being forced into a smaller space are bound to modify their direction of flow.

Effect of Design on Turbulence

Fig. 1 indicates the action of turbulence that probably occurs in an L-head engine when the piston is nearing the end of the induction stroke. It will be seen that the stream of incoming gas is directed by the shape of the valve port and pockets and the cylinder-head, so that it travels toward the side of the cylinder opposite to the valve, and causes the circulation to follow a path roughly indicated by the arrows.

The effects of turbulence are a little different in the case of an I-head engine, as indicated by Fig. 2, where the gases are represented as flowing in a direction similar to that of the piston, and spreading out as they reach it. Clearly the portion of the cylinder at x, indicated to be unoccupied by gas, will be the last to be filled. As will now be explained, turbulence has a great effect upon the quality of the gas in different parts of the cylinder.

In L-head engines, of the type indicated in Fig. 1, the spark-plug usually occupies the position shown. Owing to the plug being directly over the inlet valve, it is not actually in the path of flow of the gases due to turbulence, but only in the path taken by the new charge when entering. Evidently, then, the fresh, rich gas, which is in the main portion of the cylinder, is in rapid motion, and has, therefore, become diluted by the spent gases remaining from the previous cycle, not being so suitable for quick ignition as the gases remaining in the part directly over the inlet valve. The gas situated around the plug is quite fresh and rich and obviously will ignite more readily than that which has become mixed with the spent gases. From this it seems that the position immediately above the inlet valve is the most suitable for this type of cylinder.

The spherical-headed, I-head type of cylinder renders it more difficult to place the plug in a good position.

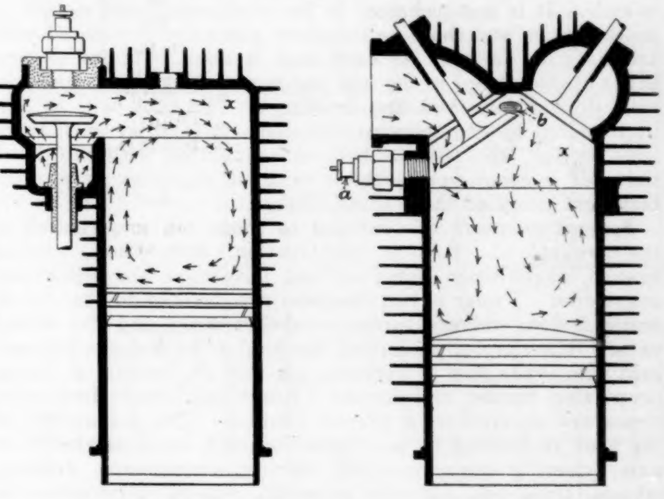


Fig. 1 Fig. 2

The position indicated at a, Fig. 2, would probably give good results as regards the richness of gas surrounding the plug, but is impossible in very many designs, because the plug would not clear the piston at the top of its stroke. The position indicated at b is very good, so far as having a rich mixture around the plug is concerned, and this location offers less difficulty for drilling and tapping out the plug orifice. It is also easier for the plug to clear the valve-gear brackets, etc.

There is another point to be considered in connection with the spark-plug position, namely, the time taken for the flame to spread throughout the entire charge after being ignited by the spark. It is necessary to consider that the time taken for complete combustion depends upon the distance between the plug and the most remote portion of the charge. Now, the whole charge becomes ignited before the piston has traveled far on the firing stroke, and therefore the distance is not great between the plug and the most distant portion of the charge. For this reason even a small change in plug position alters the distance above mentioned a large amount, and this fact is sufficient to make the correct choosing of plug position still more important. In view of this it seems advisable to place the plug as low down toward the

(*Concluded on page* 398)

Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

MOTOR-TRUCK DESIGN AND CONSTRUCTION. By C. T. Schaefer. Published by D. Van Nostrand Co., New York City. Cloth, 6 by 9 in., 312 pages, 292 illustrations.

This volume treats the construction of the modern type of commercial car in descriptive manner enabling the reader to obtain a general knowledge of the prevailing design practice for each of the various units that make up the complete vehicle. It is non-technical in its treatment, being devoid of mathematics and those calculations generally associated with treatises on design. As each unit is dealt with its various types are described in the text accompanied by numerous half-tone illustrations and line drawings. The book will be best appreciated by engineers and students unfamiliar with truck construction who wish to become acquainted with the detail units of a commercial vehicle without undertaking a more technical study of their actual design.

Several chapters are devoted to those subjects related to the powerplant. Engine construction, lubrication, cooling system, carburetion, ignition and governors are separately considered. Under drive, chapters are devoted to the clutch, transmission, universal-joint, propeller-shaft and the differential. The chapter describing the final drive includes the several axle types now in common use and the means of taking propulsion thrust and torque. Front and four-wheel-drive types are covered in a special chapter. The remainder of the book is devoted to description of such units as the front axle, steering gear, controls, spring suspensions, frames, wheels, tires, etc. In the appendix several representative truck chassis are illustrated to exemplify present-day practice in the general truck layout and relation of units.

DYKE'S AUTOMOBILE AND GASOLINE ENGINE ENCYCLOPEDIA. Published by A. L. Dyke, St. Louis. Cloth 6¼ by 9¾ in., 940 pages, 3362 illustrations.

The twelfth edition of this very comprehensive book has been further enlarged and revised. It should prove extremely valuable as a means of acquainting the novice with the construction, operation and repair of the many forms of automotive apparatus in a non-technical manner. The book covers in a most interesting and complete way the repairman's problems, and will probably be most appreciated by the garage owner and service man.

In the field of automotive engineering, it should serve as an excellent book for ground work, enabling apprentice draftsmen and students who lack technical training to grasp the practical side of automotive engineering without difficulty. The book is printed in encyclopedic form as in the past and is very completely illustrated, most of the illustrations being diagrammatic to assist in readily understanding the text.

New material has been added, covering motor trucks, tractors for farm use, motorcycles and airplanes. The Liberty engine is fully described, along with other prominent aviation engines and there is a short description of the present-day types of airplane. The subject of battery repair has been very thoroughly treated, and considerable material has been added as instructions on the testing of automotive electrical apparatus.

EVERY MAN'S GUIDE TO MOTOR EFFICIENCY. By H. W. Slauson and Howard Greene. Published by Leslie-Judge Co., New York City. Leather, 6¾ by 10 in., 288 pages, numerous illustrations.

As its name indicates this book is designed to inform the average car owner how far it is possible for him to go in making his own adjustments and repairs and how to do them simply, easily and quickly. In preparing the book the car is considered as being not a complex piece of mechanism but as built up of a number of parts, each of which is simple in itself and easily understood. For that reason each part is taken up individually and its function made clear, directions being given for keeping it in proper working order.

The book is divided into eleven sections, each relating to some one phase of the subject and where necessary these sections are further subdivided into chapters, each dealing with a particular part. The text of each chapter is supplemented by illustrations and a series of questions at the end. A feature of the book is an illustrated index preceding the text. This consists of a full-page drawing of a car with references to the section and chapter covering each part, the references being made very easy by a series of arrows running from the text around the drawing to the different parts.

AERONAUTICS. By Edwin Bidwell Wilson, Ph. D. Published by John Wiley & Sons, Inc., New York City. Cloth, 5⅝ by 9 in., 265 pages, 31 illustrations.

The book which is designed for use in the classroom is based upon a series of lectures which the author has been giving at the Massachusetts Institute of Technology. The portions of rigid and fluid dynamics which are fundamental in aeronautical engineering are included and while it is the practice at the Institute to teach the subjects in parallel courses or in rapid alternation they have been separated in preparing the book. The book is divided into three parts; the first, which is the introduction, gives the mathematical preliminaries and also treats of the pressure on a plane and a skeleton airplane. Rigid mechanics is covered in the second part, and fluid mechanics in the last. In separating the two parts it becomes necessary for the student to skip the latter part of the section on rigid mechanics and take up a portion of that on fluid mechanics. It is presupposed that the students have a thorough knowledge of calculus, including the elements of different equations and both theoretical and applied mechanics, but an effort has been made to give all the necessary mathematics. While there are a number of topics which might well be included in a work on this subject, the author has omitted them feeling that it would be much more advantageous to take them up in parallel courses on design.

LUBRICATION OF THE MOTOR CHASSIS. Arranged by Victor W. Pagé. Published by the Norman W. Henley Publishing Co., 2 West Forty-fifth Street, New York City. Folding paper chart, 28 by 33 in.

This chart is similar in arrangement to the others which the author has prepared on automotive subjects. The central feature is a plan view of a typical six-cylinder automobile chassis with all of the important bearing points requiring lubrication outlined. A side view showing the power generating and transmitting parts which require constant lubrication while in operation supplements the plan view. The importance of proper lubrication is emphasized for the so-called minor points where any lack of oil means wear at a multiplicity of joints and noisy car operation.

The instructions are divided into six parts covering the engine, electrical apparatus, clutch, change-speed gears, rear axle and miscellaneous points. In these instructions an effort has been made to treat the subject concisely but still specify the best kind of lubricant for the different bearing points, the reasons why it should be used and the correct method of application.

Increase in Maximum Pressures Produced by Preignition[1]

By S. W. Sparrow[2] *Illustrated with* Chart

WITH the high compression ratio of the aviation engine, preignition is of frequent occurrence. That extremely high temperatures result is fairly well recognized, but little attention seems to have been given to the pressures that prevail in the cylinder under these conditions. It need scarcely be pointed out that accurate knowledge of the maximum pressure in the cycle is essential to the design of an engine that shall have a known factor of safety.

In the course of the investigation of the effect of compression ratio on altitude performance, which is being conducted for the National Advisory Committee for Aeronautics at the Bureau of Standards, the curves reproduced were obtained. The dotted line shows the pressures obtained with the engine operating normally, and the solid line those obtained during preignition. A change of spark-plugs was the only difference in engine conditions between the two runs. It appears that the charge is completely burned early in the compression stroke. It is then compressed, and because of the loss of heat to the walls of the combustion-chamber the first part of the expansion line falls below the corresponding compression line. As a result the negative work of the first part of the expansion stroke is nearly equal to the positive work at the latter end, making the effective work of that cylinder practically zero.

Although the substance dealt with is not a perfect gas, the equations used in the following computation are sufficiently accurate to explain the pressure increase. Let V_1, P_1 and T_1 be the volume, absolute pressure and absolute temperature at the beginning of the compression stroke, V_2, P_2 and T_2 corresponding values at the end of the compression stroke, and V_3, P_3 and T_3 corresponding values after the charge has been burned at constant volume. For the 8.3 compression ratio used, if we assume the value of n as 1.3 in the expressions

$$P_2 = P_1\,(V_1 \div V_2)^n$$

and

$$T_2 = T_1\,(V_1 \div V_2)^n$$

Then

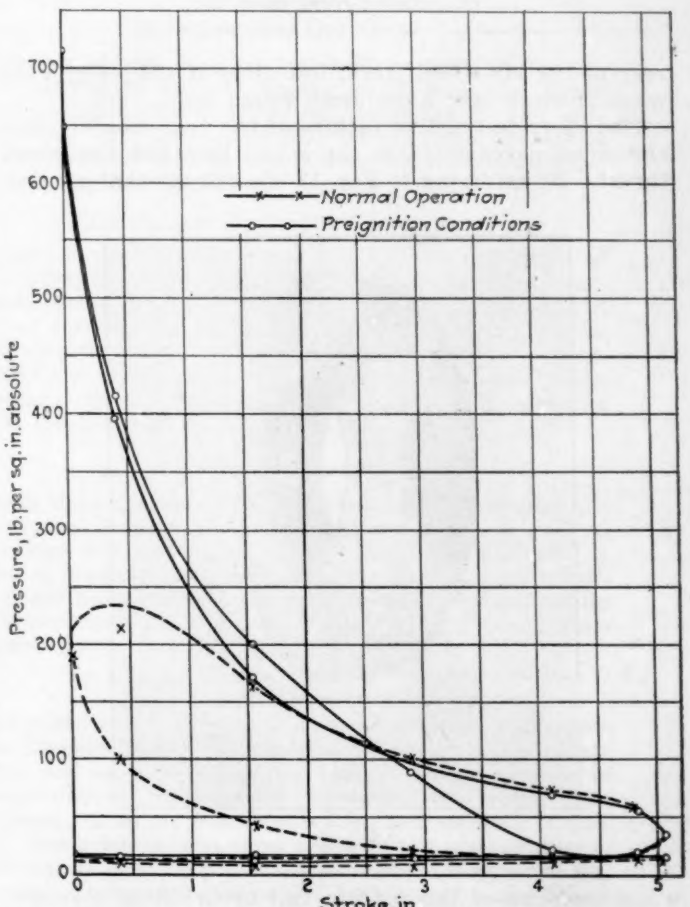
$$P_2 = P_1\,(8.3)^{1.3} = 15.7\,P_1$$

and

$$T_2 = T_1\,(8.3)^{0.3} = 1.89\,T_1$$

If the absolute temperature at the beginning of the compression stroke is 350 deg. cent. (662 deg. fahr.), the final temperature T_2 will thus be 662 deg. cent. (1224 deg. fahr.). Now assume the firing of the charge to result in a temperature increase in the mixture of 2000 deg. cent. (3632 deg. fahr.). This value is chosen small to allow for any dissociation, heat loss to walls, etc., that may exist.

$$\begin{aligned} P_2 V_2 \div T_2 &= P_3 V_3 \div T_3 \\ V_2 &= V_3 \\ P_3 &= (T_3 \div T_2)\,P_2 \\ &= [(2000 + 662) \div 662]\,P_2 \\ &= 4\,P_2 \\ &= 4\,(15.7)\,P_1 \\ &= 62.8\,P_1 \end{aligned}$$



In assuming the charge to be burned at the beginning of the compression stroke, let P_3, V_3 and T_3 represent the condition after the charge is burned at constant volume, but before it is compressed, P_2, V_2 and T_2, as before, representing the condition after the compression.

$$\begin{aligned} P_1 V_1 \div T_1 &= P_3 V_3 \div T_3 \\ V_1 &= V_3 \\ P_3 &= (T_3 \div T_1)\,P_1 \\ &= [(2000 + 350) \div 350]\,P_1 \\ &= 6.7\,P_1 \\ P_2 &= P_3\,(8.3)^{1.3} \\ &= 15.7\,P_3 \\ &= 6.7\,P_1 \times 15.7 \\ &= 105\,P_1 \end{aligned}$$

No attempt has been made to calculate accurately actual pressures or temperatures, but merely to show

[1]From Technical Note No. 14 of the National Advisory Committee for Aeronautics.

[2]M. S. A. E.—Associate mechanical engineer, automotive powerplant section, Bureau of Standards, Washington.

why the pressures obtained during preignition should be much greater than those during normal operation. The amount of this difference is, of course, influenced by the amount of dissociation, loss to combustion-chamber walls, etc. Even the curves reproduced do not adequately represent the magnitude of these pressures because with the high temperatures produced the amount of charge taken into the cylinder is somewhat decreased. At 15,000-ft. altitude where the maximum normal pressure obtained was 360 lb. per sq. in., pressures of over 950 lb. per sq. in. were obtained during preignition.

The importance of making every effort to avoid preignition is evident. Most important of all, however, is that the engineer realize how much the pressure can be increased from this cause.

WHAT MOTOR TRUCKS NEED

(*Concluded from page* 374)

rear of the six-wheel truck, lost none of the water even when running over a decidedly rough road.

The most destructive factors of the operation of vehicles upon pavements are the wheel load and the wheel thrust. By referring to Fig. 12 one can see that a heavy

FIG. 12

wheel load causes the road to fail by breaking through the pavement. If, as is the case with the tandem construction, the wheel loads are cut in two, the chances are that the wheels will seldom find spots in the pavement weak enough to break through under this reduced load, even if a 5 to 7-ton load be carried on the truck.

The twin-axle combination has a decided advantage over both regular pneumatic-tired and solid-tired types in that four brakes of 21-in. diameter are used in place of two brakes of 21-in. diameter. The six-wheel truck has a greater operating radius. Pneumatic tires permit of an increase of average speed to double that of solid tires, and the combination of four small tires on the tandem rear-drive wheels will permit of increased minimum speeds on bad roads. [The discussion of this paper is printed on page 377.]

SPARK-PLUG POSITION

(*Concluded from page* 395)

piston as the design will permit, but this rule cannot be followed blindly, because of an effect of turbulence. It should be understood that the turbulent motion of the gases is a valuable aid to the rapid spreading of the ignition; this action is so obvious that no explanation is needed here. The sooner those portions of the gas that are in motion become ignited, the more rapidly will the flame spread through the entire charge.

CONDITIONS WHICH MUST BE FULFILLED

Like most points of design, there is room for a compromise in the placing of the plug. For instance, the plug may be placed right in the path of motion of the gases, but this may mean neglecting the possibility of placing it where it would be surrounded by fresh pure mixture. Much, of course, depends upon the individual design, and this fact is much more obvious in connection with the I-head type of engine. The main difficulty in arranging for the plug position is the necessity to avoid mechanical difficulties, to place the plug where it is easily accessible and removable with ordinary tools, and also not to overlook the need for keeping the electrodes as cool as possible under extreme conditions.—*The Light Car and Cyclecar.*

RIB SPACING AND STRESS

(*Concluded from page* 391)

tance, r the radius of the bulge, the stretch of a is arc—less chord $= a^3/24\,r^2$, by a well-known property of small circular arcs. Dividing this by the original chord length a gives the strain,

$$e = a^2/24r^2.$$

Instead of r we may write its value, t/p, from hydrostatics, and obtain a stress-strain relation for the bulge

$$24et^2 = a^2p^2.$$

This, for any fixed a, p, is a hyperbola in e, t, and may be plotted on a chart with the linear relation $t = k\,e$, as in Fig. 2. Their intersection gives the actual tension generated by the air pressure p when the particular fabric represented by $t = k\,e$ covers the rib spacing a with initial tension zero. For any initial strain e_0 the hyperbola would be $24\ (e\text{-}e_0)\ t = a^2\,p^2$, or the former curve shifted laterally by an amount e_0.

AIRPLANE WOOD FINISHES

REPORT No. 85 of the National Advisory Committee for Aeronautics describes briefly a series of experiments made at the Forest Products Laboratory, Madison, Wis., to determine the comparative moisture resistance of linseed oil, impregnation treatments, condensation and oil varnishes, enamels, cellulose varnishes, rubber, electroplated and sprayed metal coatings and metal leaf coatings when applied to wood. All of the coatings except the rubber and electroplated metal, which were not developed sufficiently to make them practical, admitted moisture in varying degrees. The most effective and at the same time most practical coating was found to be that of aluminum leaf. A copy of this report can be obtained by addressing the National Advisory Committee for Aeronautics, Washington.

Current Standardization Program

RAPID progress in standardization work is usually difficult of accomplishment during the summer months because of interference of vacations and other similar conditions. Considerable advance has been made this summer, however, in connection particularly with some of the more important subjects under study by the Standards Committee.

The reports of the Divisions to the Standards Committee approved at the Standards Committee and the Society meetings at Ottawa Beach last June were regularly submitted to the members of the Society for letter ballot which was counted on Aug. 20; the results of this are published elsewhere in this issue of THE JOURNAL.

Radiator Division

A new division of the Standards Committee known as the Radiator Division was formed to review the radiator situation thoroughly and to outline recommendations for such standards pertaining to radiators and their assembly on passenger cars and trucks as are considered feasible at this time. A meeting of the Division was held in Buffalo on July 12. Tentative recommendations were made relative to header flange and bolt dimensions, pressure tests, header plate and gasket thicknesses, drain-cocks and overflow tubes. The preliminary conclusions are being circularized and it is expected definite recommendations will be made at a subsequent meeting of the Division.

Tire and Rim Division

The Tire and Rim Division's program of work was concluded in large part at the first of this year. There are, however, some important matters to be determined in connection with pneumatic tires and wheels. Among these is the possibility of accomplishing standardization which will permit of tire and rim interchangeability as between front and rear wheels on commercial vehicles equipped with pneumatic tires within the range of 5, 6, 7 and 8-in. tire sizes. Another subject is that of reducing the present number of standard pneumatic tires and rims to a series all of which, with the exception of the 30 x 3½-in. regular and the 31 x 4-in. oversize clinchers, will be mounted on 24-in. wheels. These topics were considered carefully by members of the Tire and Rim Division at its meeting held on Aug. 4 and have been referred to the automotive industries which would be affected by the standardization.

Truck Division—Wheels Subdivision

One matter of great import before this Division is hub standardization. It was intended originally to discuss hubs for both rear and front wheels but upon analysis of present conditions and the possibility of securing results it was decided that the standardization of front-wheel hubs only should be considered at present. If in view of the difficulties to be overcome front-wheel hub standardization can be accomplished, work will be continued to include rear-wheel hubs which are considered by far the most difficult part of the procedure. The Automotive Metal Wheel and the Automotive Wood Wheel Manufacturers' Associations are actively cooperating in the deliberations and it is anticipated that a definite report will be ready for consideration by these bodies and the Wheels Subdivision at a not far distant date.

Lubricants Division

With the increasingly important problems in connection with petroleum production and consumption there has come before the Society the subject of standardization of various types and grades of lubricants. A new division known as the Lubricants Division was therefore formed and held a meeting on Sept. 7 to review the lubricants situation and decide upon a program looking toward the standardization of lubricants for the automotive industries particularly. A questionnaire has been sent out to these industries for the purpose of obtaining uptodate detailed information relative to the types and grades of lubricants recommended for various applications. The American Petroleum Institute is cooperating with the Society in this work and although it is realized that the problems to be encountered are difficult and will require considerable study, it is believed that much can be accomplished that will be of immense value to both the petroleum producers and the users of lubricating materials.

Frames Division

The Society has for some time published specifications for passenger-car frames. These are not, however, considered uptodate. The reestablished Frames Division has therefore started to prepare revised and more complete specifications, it having held a meeting on Sept. 8 and taken steps to obtain detailed information with regard to current practice and suggestions as to what its program of standardization should include.

Transmission Division

A meeting of this Division was held on Sept. 20 to consider a number of subjects, among which were disc clutch dimensions, transmission drive for speedometers and universal-joints. It is anticipated that definite recommendations from this Division will be reported to the Standards Committee meeting next January.

Electrical Equipment Division

Among the matters assigned to this Division are insulated electric cable, spark-plugs, automobile storage batteries, magneto dimensions, generator and starting motor mountings and electrical instruments for isolated electric lighting plants. Subdivisions have been working on these subjects in cooperation with the industries and great progress has been made, particularly in the direction of a revision of the existing S. A. E. specifications for insulated electric cable.

Engine Division

Among the subjects before this Division are carbureter air-cleaners and heaters, valve tappets, fan belts and pulleys, piston-rings and grooves, flywheel housings and mufflers. A number of these have already been standardized by the Society but are being reconsidered to bring them into conformity with best current practice. These matters were among those considered by the Division at a meeting held on Sept. 22.

Miscellaneous Division

Among the subjects which were scheduled for the meeting of this Division on Sept. 24 were the extension of the standard for fuel and lubrication pipe-fittings and the preparation of recommendations for taper pipe-threads, ball studs, horn mountings, screw and bolt classification and marking of steel stock. Subdivisions have been active in the investigation of the several subjects before the Division and it is expected that a number of recommendations will be reported to the Standards Committee at the Annual Meeting of the Society in January.

American Engineering Standards Committee

Standardization work of the Society in connection with the American Engineering Standards Committee is proceeding slowly but definitely. The S. A. E. representatives on the American Engineering Standards Committee are Chairman B. B. Bachman of the Standards Committee, Past-President Charles M. Manly and General Manager Coker F. Clarkson.

This Society and the American Society of Mechanical Engineers have been delegated joint sponsors for screw-thread standardization and a Sectional Committee on Screw Threads has been appointed by the two Societies under the plan of procedure. The main work of this Sectional Committee will

be to review carefully the report recently completed by the National Screw Thread Commission and to serve as a medium through which the recommendations given in this report can be correlated with American and foreign standards and promulgated in American industrial practice.

This Society and the American Society of Mechanical Engineers have been designated by the American Engineering Standards Committee as sponsors for the subject of ball bearings and a Sectional Committee has been appointed. The ball bearing standards of the Society which are now in general practice will be reviewed and correlated insofar as possible with foreign practice so as to secure the greatest possible international standardization.

The Society has accepted the joint sponsorship with the Bureau of Standards for the standardization of automotive storage batteries. Much work has been done by the Subdivisions of the Electrical Equipment Division and the Electric Transportation Division of the Standards Committee, as well as by the Bureau of Standards and the Motor Transport Corps. This work will be reviewed with the thought of establishing complete standard storage-battery specifications which will probably include overall dimensions, tests and methods of rating. The American Engineering Standards Committee has been requested to undertake the standardization of gears and the American Society of Mechanical Engineers and the American Gear Manufacturers' Association have been delegated sponsors in this connection. It is expected that the work will include only such types of gears as are sold from stock for general mechanical purposes and not the types of gears usually employed in automotive work. The Society will probably appoint only one representative on this Sectional Committee for the time being. If gears which are used extensively by the automotive industries come under consideration, the Society will request that it be delegated as one of the sponsors and more extensive representation secured on this Sectional Committee.

There are now 24 Divisions of the Standards Committee, most of which have subjects assigned and in active preparation for definite recommendations. Among these are a new series of non-ferrous metal specifications intended to be more comprehensive than the present ones, and a large amount of data pertaining to physical properties and uses of all classes of S. A. E. steels. Such work necessarily requires a large amount of time and study, as the subjects are very extensive and will probably affect nearly all branches of the automotive industries using metals in their products.

THE SHORT-HAULAGE PROBLEM

WHEN we look at the picture presented by our railroad situation today we are indeed startled. Our 2,400,000 freight cars carry only about one-half their capacity and move about 25 miles per day per car. Box cars average something over 35 tons capacity, and yet hundreds of thousands of them are carrying less-than-carload freight, and hauling perhaps not more than 5 tons. While it is impossible to give the exact figures, we have a record of one investigation of the Cleveland, Cincinnati, Chicago & St. Louis Railway in which it was found that the average less-than-carload freight for a certain six-months' operation was about 5 tons. Nearly one-half of all the tonnage carried in the Eastern district is coal.

Very few records are kept by railroads as to their terminal and short-haul costs. From the best figures obtainable, it seems that their terminal charges amount to about 10 cents per 100 lb. at each end of the line. Terminal charges include the switching and placing of the car, loading and unloading, the clerical work necessary to take care of this work, and general overhead charges to be proportioned to these operations. An authority has said that it costs about $35 to deliver a car in Manhattan or Brooklyn after it reaches the Jersey terminal, while in Chicago it costs something like $10.35 and in a small city like Binghamton, N. Y., $1.80. The 20-cent terminal charge estimate does not cover a line haul, which is less than 1 cent. From this it may be deduced that the big charges are for loading, unloading and handling, and that unless a shipment goes a sufficient distance to warrant all this labor, the practice is uneconomical.

Fifteen cents per hundredweight is a fair charge for cartage at each end of the line when considering less-than-carload shipments. Adding to this the terminal charges mentioned, we find that the transportation cost of this shipment, exclusive of the cost of the line haul, from door to door is 50 cents. From this it is reasonable to infer that for any locality to which the motor truck can deliver for 50 cents per 100 lb. or less it would be more economical to ship by motor truck. This does not take into consideration the service meaning a delivery in a few hours, which on the railroad might take two weeks. It also covers only that merchandise which is shipped in the same manner by a motor truck as by railroad.

It would seem reasonable to suppose that on all distances under 50 miles the railroad is losing money. If it is necessary to tax the long haul to make up for short-haul loss, it would seem practical to do away with the business which is carried at a loss. The thousands of cars, containing package freight, which come into stations to be broken up and redistributed to other roads, block the entire traffic stream and tie up through freight because an arrangement has not been made to transfer these small-lot shipments immediately by vehicles from the incoming cars to the railroad that is to carry it out. This delay holds up thousands of cars every week.—C. W. Reid in *Transportation World.*

TRACTOR DRAWBAR-PULL

(*Concluded from page* 394)

over the ground. This will decrease the power available at the drawbar and in addition to this there will be a decrease in drawbar-pull in proportion to the increase in speed.

To make the case as clear as possible it will be assumed that a tractor weighing 5000 lb. has an engine which delivers 25 hp. at the crankshaft. The transmission efficiency will be assumed to be 80 per cent which leaves 20 hp. to move the tractor and pull the load. It will be assumed further that it requires a pull equal to 600 lb. to move the tractor and overcome slippage effects and lug action, on the level. Table 4 gives the drawbar-pull in pounds which would be available under these conditions at the rates of travel indicated.

Thus it appears that these factors, which vary widely, have a direct effect upon the drawbar-pull which a tractor can deliver, making it necessary for a dealer to know conditions before he can make definite recommendations regarding the load that the tractor can be expected to pull. The figures given in this article apply to a 5000-lb. tractor with an engine capable of delivering 25 hp. at its rated speed. Some assumptions have been made. Many data desired are not available. Under these conditions the dealer is left largely to his own resources in studying the adaptability of any given tractor to local conditions.

If attention is paid to the results obtained by a number of customers it will be possible to accumulate a fund of working knowledge which can be drawn upon for the purpose of making reliable recommendations that will fit most cases which way arise.

The important thing to keep in mind is that there are conditions entirely independent of the tractor which influence drawbar pull.—E. A. White in *Farm Implement News.*

Activities of the Sections

AT the beginning of the 1920-1921 season it is interesting to look back at the work which the Sections have done in the past year. It is sometimes not realized how many of the articles which appear in THE JOURNAL have their origin at Section Meetings. In the past year over 50 papers were presented in this way, touching many phases of the automotive field. A complete list of these shows the scope covered.

Papers Presented at Section Meetings

BUFFALO SECTION

John Younger—Flexibility in Organization
C. M. Tichenor—Organization of Air Service Mechanics Regiments
W. A. Darrah—Japanning Practice
J. Edward Schipper—Current Development of Automotive Industries
John G. Willett—Controlling and Atomizing Fuel by Variable Engine Pressures

CLEVELAND SECTION

Ferdinand Jehle—Use of Aluminum in Present and Future Motor Cars
S. Vance Lovenstein—Wood Truck Wheels
A. L. Putnam—Single-Disc Metal Wheels
C. S. Walker—Wire Wheels
Burgess Darrow—Data on Pneumatic Tires and Rims Used on Trucks
E. W. Templin—What Motor Trucks Need to Supplement Pneumatic-Tire Equipment.
W. E. Shively—Why Use Pneumatic Tires for Trucks?
M. D. Scott—Experiences in the Development of Pneumatic Tires and Motor Trucks
Carl A. Schell—Flexible Shaft-Joint Progress
D. W. Douglas—The Airplane as a Commercial Possibility
J. H. Hunt—Battery Ignition
A. D. T. Libby—Advantages of Magneto Ignition
W. E. Shively—Past, Present and Future of Highway Transportation
E. W. Templin—Design of the Six-Wheel Truck
Armin Elmendorf—Plywood and Its Uses in Automobile Construction

DETROIT SECTION

Capt. O. W. Koester—Wrecked Machinery Repairs on Interned German Ships
Symposium on Pneumatic Tires
C. C. Hanch and H. E. Coffin—The Automotive Situation in the Allied and Associated Countries
Com. S. P. Fullinwider—North Sea Mine Barrage
M. C. Horine—A Study of Road Impact and Spring and Tire Deflection
H. C. Bierbaum—Non-Ferrous Alloys
Zay Jefries—Aluminum Alloys
L. A. Stewart—Necessity for Cooperation between the Petroleum and the Automotive Industries

INDIANA SECTION

Edward A. Deeds—The Engineer in Industry
R. E. Carpenter—Developments in Alloyed Aluminum
W. R. Shimer—Essentials of High-Grade Steel Manufacture
C. F. Kettering—Combustion of Fuels in Internal-Combustion Engines

METROPOLITAN SECTION

H. C. McBrair—Direct Multiple-Speed Automobile Rear-Axle Drive
G. J. Mercer—Trend of Automobile Body Design
J. F. Fox—Method of Analyzing Torsional Vibrations in Crankshafts and the Elimination of Critical Speeds
F. M. Lewis—The Critical Speeds of Torsional Vibration
G. M. Rollason—Alloyed Aluminum as an Engineering Material
A. F. Masury—A Study of Road Impact and Spring and Tire Deflection
W. V. Logan—The Development of Pneumatic Truck Tires
L. G. Nilson—Piston-Rings

MID-WEST SECTION

V. R. Gage—Some Factors of Engine Performance
O. E. Griner and M. A. Smith—Heavy-Duty High-Speed Engine
John A. Secor—Kerosene as a Tractor Fuel
N. G. Anderson—Truck Maintenance
R. E. Berg—Service
Arnold P. Yerkes—Increasing the Utility of the Tractor
E. H. Sherbondy—Supercharging of Airplane Engines

MINNEAPOLIS SECTION

R. S. Kinkead—Motorized Artillery in the A. E. F.
Symposium on Tractor Wheels
E. R. Greer—Four-Wheel-Drive versus Caterpillar Tractor
Lorn Campbell, Jr.—Welding and Its Relation to the Repair Industry
D. W. Onan—Salvage and Remachining
Symposium on Bearings
A. F. Moyer—Tractor Weight and Drawbar-Pull
C. W. Pendock—Engine Design from a Production Standpoint

PENNSYLVANIA SECTION

O. A. Hollis—Dynamics of the Conservation of Energy
A. K. Brumbaugh—Transcontinental Truck Test
Com. H. C. Richardson—Factors Involved in High Airplane Speed at Great Altitudes.
Hubert C. Verhey—Marine Heavy-Oil Installation Practice and Development Possibilities
James M. Schoonmaker, Jr.—Evolution of Airplanes
C. F. Kettering—Engineering Possibilities as Indicated by the Progress of Science

As a variation of the usual evening sessions the meetings sometimes took the form of inspection trips to manufacturing plants, and occasionally a joint meeting of two Sections was held when a particularly interesting subject was under discussion.

During the summer months the regular monthly meetings were suspended although a number of the Sections took this opportunity to hold outings which were well attended by members and a number of ladies who came as their guests. Among these affairs were the Pennsylvania Section outing at Swarthmore which occupied the afternoon and evening of May 22, and the Metropolitan Frolic which was given at Bear Mountain on Aug. 12.

The Sections have without exception realized the necessity and advantage of informal personal contact among members and as a means for promoting this have adopted the general plan of preceding the monthly technical session with a dinner. These dinners are well attended and serve advantageously to fill the time between the close of the office or factory and the hour of the technical session.

The Council of the Society has always realized the importance of the work done by the Sections and recognized this in previous years by the appropriation of various sums to be used in paying certain expenses incurred in connection with the local technical meetings. During the past year this

appropriation was at the rate of $250 to each Section plus $1 per Section member. At the June meeting of the Council the work of the past year was reviewed and it was decided to increase this amount substantially. During the coming year each Section will receive from the Society $500 plus $1 per Section member. These sums together with the money received from local membership dues, which are now uniformly $5 in all the Sections, will, it is believed, enable the Section officers to provide even better programs during the ensuing year.

Proposed New Sections

The present Sections are eight in number. All of these have been active for a number of years and are firmly established. The war and the chaotic conditions which resulted delayed for a time the formation of new Sections. From time to time members of the Society have expressed a desire that various additional Sections be organized. For these to be successful it is, however, necessary in each case that a considerable number of members possessing not only the enthusiasm needed to initiate the movement, but the staying power to maintain it well, become enlisted. In the past few months it has become increasingly evident that a number of new Sections are earnestly desired by many members of the Society who fully appreciate the advantages to be derived from the Sections but are located too far from any of the existing ones to be able to attend their meetings.

An analysis of the geographical distribution of the Society's membership indicated several cities which might be considered as logical additional centers for the work of the Society, viewing also the present and future importance of these in the automotive field. With these factors in mind a number of districts were selected. Each member of the Society in these territories was asked to give his opinion as to the desirability of forming a Section and also whether in the event of such organization he would join the local body. The replies so far received indicate an almost unanimous approval of the proposal and as a result plans are now actively under way for holding preliminary meetings for the purpose of organizing a Section at Boston and making permanent the temporary Section at Washington. Similar action will be taken with respect to other localities where a sufficiently large S. A. E. membership is available and adequate desire for a Section is manifested.

Meetings Held and Scheduled

The first Section meeting of the autumn season was held on Thursday, Sept. 16, by the Metropolitan Section in New York City at the Automobile Club of America. Capt. George E. A. Hallett, in charge of the powerplant division of the Air Service at McCook Field, treated the subject of ignition from the point of view gained in his extensive research. Motion pictures of manufacturing processes and tests were shown. The meeting was as usual preceded by a dinner in the grill room of the club.

An account of the development of the fuelizer produced by the Packard Motor Car Co. was given by L. M. Woolson of that company before the Cleveland Section on Sept. 17.

The subject of the first meeting of the Detroit Section's season which opened on Sept. 24 was Recent Developments in the Design and Manufacture of Passenger-Car Wheels. The speakers were C. C. Carlton, F. M. Germane and A. L. Putnam.

For Oct. 8 the Mid-West Section has scheduled an internal-combustion engine fuel discussion, in which it is expected that Past-President Kettering, H. L. Horning, D. P. Davies, E. A. Johnston, P. S. Tice and F. C. Mock will take part.

Sections Officers

A complete list of the officers of the various Sections for the coming year is given below.

BUFFALO SECTION

Chairman .... C. F. Magoffin
Vice-Chairman .... E. T. Mathewson
Secretary .... R. Chauveau
Treasurer .... J. C. Talcott

CLEVELAND SECTION

Chairman .... H. G. Welfare
Vice-Chairman .... H. C. Snow
Secretary .... A. E. Jackman
Treasurer .... K. B. Britton

DETROIT SECTION

Chairman .... E. G. Gunn
Vice-Chairman .... Howard A. Coffin
Secretary .... M. Howard Cox
Treasurer .... E. W. Seaholm

INDIANA SECTION

Chairman .... Chester S. Ricker
Vice-Chairman .... D. L. Gallup
Secretary .... B. F. Kelly
Treasurer .... J. E. Padgett

METROPOLITAN SECTION

Chairman .... A. M. Wolf
Vice-Chairman .... A. C. Bergmann
Secretary .... M. C. Horine
Treasurer .... L. G. Nilson

MID-WEST SECTION

Chairman .... George T. Briggs
Vice-Chairman .... Dent Parrett
Secretary .... L. S. Sheldrick
Treasurer .... Walter S. Nathan

MINNEAPOLIS SECTION

Chairman .... A. W. Scarratt
Vice-Chairman .... R. S. Kinkead
Secretary .... C. T. Stevens
Treasurer .... J. S. Clapper

PENNSYLVANIA SECTION

Chairman .... G. W. Smith, Jr.
Vice-Chairman .... A. K. Brumbaugh
Secretary .... H. Hollerith, Jr.
Treasurer .... J. T. O'Neill

The addresses of the secretaries of the different Sections were printed on page 305 of the September issue of The Journal.

LACK OF RAILROAD FACILITIES

Freight traffic has increased so rapidly in the United States in the past few years that it has completely outgrown the carrying capacity of the railroads. As a result, it is now necessary for the roads to devise a practical plan for increasing their transportation service. This can be done only by making extensive additions of new facilities and equipment, including freight cars, locomotives, yards and track terminals, or by making a much more efficient use of all of the various facilities and equipment that are available at the present time.

The railroads cannot carry out the plan first suggested because under present conditions they are unable to obtain a sufficient amount of new capital; nor would it be possible for them to provide new facilities in time to relieve the present emergency even if the capital were available. They must therefore, rely on making a maximum use of existing facilities and equipment, with the cooperation of all of the other interests concerned, the shippers of freight, receivers of freight and railroad employes.—Report of the Chamber of Commerce of the United States.

PERSONAL NOTES OF THE MEMBERS

Charles L. Allmond, formerly mechanical engineer with Smith, Hinchman & Grylls, Detroit, is now employed as draftsman with the Ford Motor Co., Highland Park, Mich.

Alfons Altenberg has accepted a position as chief engineer of the power and lighting plants division of the Kohler Co., Kohler, Wis.

Oscar G. Anderson, formerly draftsman with the Lincoln Motor Co., Detroit, has become associated with the Lake Side Iron Works, Marquette, Mich.

Walter H. Barling has accepted a position as supervisory engineer for the Wittemann-Lewis Aircraft Co., Hasbrouck Heights, N. J. He was formerly aeronautical engineer in the engineering department, Air Service, McCook Field, Dayton, Ohio.

F. J. Bartella, who was formerly manager of equipment sales at the Chicago branch of A. R. Mosler & Co., New York City, is now connected with the Chicago office of the American Bosch Magneto Corporation, Springfield, Mass.

Vincent Bendix is now associated with the Bendix Engineering Works, 327 South La Salle Street, Chicago. He was formerly consulting engineer with the Eclipse Machine Co., Elmira, N. Y.

Lloyd I. Birckelbaw has accepted a position as civilian employe on engine work at the Rockwell Aviation Field, Coronado, Cal.

A. K. Bondar has resigned as designer for the Hannevig Sikorsky Aircraft Co., New York City, to accept a position as aeronautical engineer for the General Motors Corporation, Dayton, Ohio.

L. J. Butzow, formerly chief draftsman of the General Motors Laboratories, Detroit, has accepted a position as engineer with the Sunny Home Electric Co., also of that city.

Joseph B. Cary has been elected vice-president of the American Malleables Co., Lancaster, N. Y. He was formerly operating manager of the Air Reduction Sales Co., New York City.

Ralph C. Chesnutt has resigned as designing engineer for the Bethlehem Motors Corporation, Allentown, Pa. He has not announced any plans for the future.

H. W. Christensen has accepted a position as production manager of the Highway Motors Co., Defiance, Ohio. He was formerly chief draftsman in the truck engineering department of the Packard Motor Car Co., Detroit.

K. G. Collins has been appointed superintendent of the calorizing division of the Connecticut Electric Steel Co., Hartford, Conn. He was formerly engineer of tests with the Henry Souther Engineering Co., also of that city.

Charles A. Cook, formerly chief engineer for the King Motor Car Co., Detroit, has accepted a position with the Haynes Automobile Co., Kokomo, Ind.

Everett J. Cook has severed his connection with the Chicago Standard Axle Co., Chicago, to accept a position with the O. K. Truck Co., Muskogee, Okla.

Alberto de Lavandeyra has been elected vice-president of production of the Prado Automobile Co., 25 Church Street, New York City. He was formerly consulting engineer for Bausch Machine Tool Co., Springfield, Mass.

George J. Dietz, Jr., who was formerly assistant engineer with the International Fabricating Corporation, Wilkes-Barre, Pa., is now associated with the Owen Magnetic Motor Car Corporation, also of that city.

A. W. Dietzel has resigned as general superintendent of the tractor works of the Moline Plow Co., Moline, Ill., to accept the position of factory manager with the Highway Trailer Co., Edgerton, Wis.

G. V. Domarus, Jr., has accepted a position as general sales manager for the Erd Motor Co., Saginaw, Mich.

James F. Donahue, western sales manager of the Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y., has been appointed vice-president and general manager of the Foster Bolt & Nut Mfg. Co., Cleveland.

J. E. Duffield has accepted the position of general sales manager of Anderson & Gustafson, Inc., Transportation Building, Chicago. He was formerly sales manager of the New Era Spring & Specialty Co., Grand Rapids, Mich.

George N. Duffy, formerly with the Curtiss Aeroplanes & Motors, Ltd., Toronto, Ont., is now production engineer with the Willys-Overland, Ltd., West Toronto, Ont.

J. Frank Duffy has accepted a position as engineer and production manager of the William R. Johnston Mfg. Co., 451 East Ohio Street, Chicago. He was formerly manager of the Sumter works of the Splitdorf Electrical Co., Sumter, S. C.

John S. Erskine, formerly chief draftsman for the McCord Mfg. Co., Detroit, has entered the employ of the Stover Mfg. Co., Freeport, Ill.

Gerald Fitzgerald has severed his connection with the sales department of the Nordyke & Marmon Co., Indianapolis, and is now manager of the Marmon St. Paul Co., St. Paul, Minn.

Carl B. Frevert has accepted a position as tractor designer for the Advance-Rumely Co., Battle Creek, Mich. He formerly held the same position with the Hart-Parr Co., Charles City, Iowa.

Paul H. Geyser is no longer chief engineer and assistant general manager of the W. W. Shaw Livery Co., Chicago, but has accepted a position as manager of the Yellow Cab Mfg. Co., 5801 West Dickens Avenue, also of Chicago.

Samuel W. Gray, who was formerly mechanical engineer with Reed & Glaser, Indianapolis, has accepted a position as production manager of the Acme Works, Inc., also of that city.

J. R. Harbeck has been elected vice-president of the Willys Corporation, 52 Vanderbilt Avenue, New York City.

Harry E. Harris, formerly president and chief engineer with Hubbard & Harris, Inc., Bridgeport, Conn., is now proprietor of the Harris Engineering Co., of that city, with offices at 1047 Broad Street.

Lui F. Hellman has accepted a position with the Air Brake Safety Appliance Co., Indianapolis. He was formerly assistant chief tool designer in the aviation section of the Nordyke & Marmon Co., also of that city.

C. A. Hanneuse has become president and general manager of the Henneuse Tractor Co., Sacramento, Cal.

J. H. Hertner has accepted a position with the Hertner Electric Co., West 114th and Locust streets, Cleveland. He was formerly engineer for the Baker R. & L. Co., in the same city.

Hugo Hoffstaedter, who organized the Polack Tyre & Rubber Co., New York City, in 1912, has resigned as president and general manager. His interest in the business has been purchased by the Buckeye Rubber Products Co., Cleveland. No announcement has been made of Mr. Hoffstaedter's plans for the future.

L. H. Holdeman, formerly chief engineer for the Dayton Stamping & Tool Co., Dayton, Ohio, has accepted a similar position with the Linderman Steel & Machine Co., also of that city.

Cleon R. Johnson has resigned as manager of the development department of the Goodyear Tire & Rubber Co., Akron, Ohio, and has accepted the position of vice-president and treasurer with the Ramsdell Brothers Co., Cleveland. In his new position he will have charge of truck tire sales.

George L. McCain has been promoted to inspection engineer for the Packard Motor Car Co., Detroit. He formerly held the position of carriage chassis engineer.

Alexander Matheson has been elected vice-president of the Motor Parts Co., Boston. He was formerly a member of the faculty of the Motor Transport Training School, Camp Holabird, Baltimore.

Alan B. Neumann, formerly assistant development engineer with the International Harvester Co., Chicago, is now connected with the Stewart-Warner Speedometer Corporation, Diversy Boulevard, also of that city, in the capacity of assistant carbureter engineer.

Joseph P. Nicholson has accepted a position in the technical department of the Topping-Sanders Co., 129 Fort Street, Detroit. He was formerly layout draftsman for the Scripps-Booth Corporation, located in the same city.

Charles D. Norris, formerly engineer and designer for the Burlington Truck Co., Chicago, has entered the employ of the Viani Concrete Mold Co., also of Chicago.

Arthur F. Ochtman has accepted a position as head of the testing department in the engine division of Wellman-Seaver-Morgan Co., Akron, Ohio. He was formerly service man for the Van Blerck Motor Co., Monroe, Mich.

H. F. Peavey has resigned as assistant chief engineer of Stevens Duryea, Inc., Chicopee Falls, Mass., to associate himself with the American Bosch Magneto Corporation, Springfield, Mass.

George E. Pope is no longer service engineer for the Locomobile Co. of America, Bridgeport, Conn., having accepted a position as maintenance engineer for Hare's Motors, Inc., 16 West 61st Street, New York City.

S. C. Shipley, formerly assistant professor of mechanical engineering, University of Minnesota, Minneapolis, has been appointed professor of mechanical engineering at Robert College, Constantinople, Turkey.

Charles A. Singer, Jr., who was formerly export manager and assistant in production with the General Ordnance Co., New York City, has entered the employ of E. S. Partridge & Co., Inc. 1826 Broadway, New York City.

P. W. Steelsmith has accepted a position as assistant in the testing department of the Atchison, Topeka & Santa Fe Railway Co., Topeka, Kan.

Paul W. Tietsche has severed his connection with the American Die Casting Co., Indianapolis, to accept a position as tool engineer with the Natco Engineering Co., also at Indianapolis.

Charles A. Trask has resigned as mechanical superintendent with the Rockwood Mfg. Co., Indianapolis, and has accepted a position as factory manager for the National Metal Products Co., which is located in the same city.

John D. Van Vliet has accepted a position as designing engineer with the Chile Exploration Co., New York City, He resigned as chief engineer of the Cantilever Aero Co., also of that city, some time ago.

Charles R. Vogel has severed his connection with the American Telephone & Telegraph Co., New York City, and accepted a position with the Oxweld Acetylene Co., Newark, N. J.

W. G. Vollmer has accepted a position with the Baptiste Tent & Awning Co., 612 North Third Street, St. Louis. He was formerly with the Liberty Auto Lock, also of that city.

H. J. Wendland, of Jackson, Tenn., has recently been appointed superintendent of the oxygen plant of the Air Reduction Sales Co., St. Louis.

Charles F. Willard, who was formerly chief engineer of the aeronautical department of the Aeromarine Plane & Motor Co., New York City, has become consulting engineer for Witteman-Lewis Aircraft Co., 140 West 58th Street, also of that city.

L. L. Williams has severed his connection with the Automotive Service Co., Cleveland, to become factory manager of the E. J. Thompson Co., 214 Lexington Avenue, Pittsburgh.

H. Putnam Wood has accepted a position as general superintendent of the Universal Body Corporation, Mishawaka, Ind. He was formerly in charge of mechanical body design with Brewster & Co., Long Island City, N. Y.

CARBURETION OF HEAVY FUELS

(*Concluded from page* 392)

ter, owing to various functional complications which result therefrom in other directions. Still the fact remains that whereas with ordinary gasoline the present emplacement leaves nothing to be desired, it is not quite good enough for easy starting on heavy or low-grade fuel, and a revision of this part will, in my opinion, soon be necessary with the advent of inferior fuels.

Effect of Air Leakages

Another very vulnerable part of most carbureters and one which is the unsuspected cause of much starting trouble, even with good fuel, is the wear in the throttle bearings. The effect of air leakage here varies according to the design of the carbureter and the degree of starting and slow-running trouble that results, depending upon the situation of the starting jet in relation to the source of leakage.

But even under the best conditions it is a very injurious factor in starting for the reasons mentioned above, namely, that it means the admission of uncarbureted air under conditions when it is vitally necessary to take the utmost advantage of the local velocity to produce a maximum degree of disintegration. Some carbureter makers are realizing the importance of this in their latest models and providing readily replaceable bearings, but many designers still seem to ignore the fact that wear can and does take place quickly at this point and make no provision for the replacement of worn parts here.

This may appear to be merely hypercriticism and so indeed it might truthfully be termed were we dealing with the good 0.710 fuel of bygone days. A very whole-hearted revision of present methods will be necessary if we are to cope successfully with the fuel troubles that without doubt will be inflicted upon us in the near future.—L. T. Mantell in *The Motor*.

REPORT OF THE FEDERAL ELECTRIC RAILWAYS COMMISSION

AFTER 15 months of deliberation the Federal Electric Railways Commission arrived at various conclusions some of which are summarized as follows:

> The electric railway industry as it now exists is without financial credit and is not properly performing its public function. The great increase in the use of private automobiles, the jitney and motor buses has introduced a serious although not a fatal competition to the electric railway. These forms of public motor conveyance when operated as public carriers should properly be subject to equivalent regulatory provisions.
>
> All labor disputes should be settled voluntarily or by arbitration, and an award of an arbitration board should be final and binding upon both parties. It is intolerable that the transportation service of a city should be subject to occasional paralysis, whether by strikes or lockouts.
>
> Public ownership and operation of local transportation systems whether or not it be considered ultimately desirable, is now, because of constitutional and statutory prohibitions, financial and legal obstacles, the present degree of responsibility of our local governments, and the state of public opinion, practicable in so few instances that private ownership and operation must as a general rule be continued for an extended period.

Applicants *for* Membership

The applications for membership received between Aug. 14 and Sept. 18, 1920, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALBRECHT, JOHN H., chief engineer, Freeman Motor Co., *Cleveland*.

ALCURE, LIEUT. JOHN F., chief inspector, *Camp Holabird, Md.*

ALLEN, CARLOS H., engineer, New Departure Mfg. Co., *Bristol, Conn.*

ALTON, DARREL D., designer, Southern Motor Mfg. Association, Ltd., *Houston, Tex.*

APPLE, LYNFORD A., manager, General Motors Truck Co., *Bloomfield, N. J.*

BABCOCK, WALTER F., assistant chief draftsman, Foote-Burt Co., *Cleveland.*

BAILLY, LOUIS, chief engineer, Ohio Municipal Equipment Co., *Columbus, Ohio.*

BAKER, DAVID B., assistant chief engineer, International Harvester Co., *Chicago.*

BALL, LIEUT.-COL. GEORGE E., Motor Transport Service, 230 East Ohio Street, *Chicago.*

BARDWELL, HAROLD E., engineer, International Motor Co., *New York City.*

BELANGER, J. L., Standard Welding Co., 1280 West 73rd Street, *Cleveland.*

BENJAMIN, B. R., superintendent of experiments, International Harvester Co., *Chicago.*

BIRD, D. A., superintendent, Cleveland Radiator Co., *Euclid, Ohio.*

BLESSING, M. A., manager of sales, Jones & Laughlin Steel Co., *Chicago.*

BLEVINS, JACQUES E., president, Southern Motor Mfg. Association, Ltd., *Houston, Tex.*

BOOTH, HARRY T., aeronautical engineer, Curtiss Aeroplane & Motor Corporation, *Garden City, N. Y.*

BORGERD, W. F., assistant chief engineer, tractor works, International Harvester Co., *Chicago.*

BOYER, H. H., chief draftsman, Holmes Automobile Co., *Canton, Ohio.*

BRADLEY, C. S., district sales manager, Jones & Laughlin Steel Co., *Pittsburgh.*

BROADBENT, EARL ROBERT, staff engineer, Sinclair Refining Co., 111 Washington Street, *Chicago.*

BURGER, L. F., chief stationary engine engineer, International Harvester Co., *Chicago.*

BURTCH, JOEL, designing engineer, Glenn L. Martin Co., 16800 St. Clair Avenue, *Cleveland.*

BURTIS, C. L., sales engineer, Thermoid Rubber Co., *Chicago.*

BUTCHER, LOWELL R., experimental engineer, Porter Tractor Co., *Newton, Iowa.*

BUTLER, E. J., assistant engineer, Freeman Motor Co., *Cleveland.*

CAPRON, W. A., tank, tractor and trailer division, Ordnance Department, *Washington.*

CASE, L. B., chemist, General Motors Corporation, *Detroit.*

CASSERLY, GRAHAM, assistant to research engineer, Locomobile Co. of America, *Bridgeport, Conn.*

CHAILLIEY, GEORGE A., American manager, Panhard-Levassor, *Paris, France.*

CHAMBERS, ALEXANDER K., district service manager, American Bosch Magneto Corporation, *Chicago.*

CHIEVITZ, WILLIAM J., engineer, Cleveland Automobile Co., *Cleveland.*

CHRISMAN, C. R., draftsman, Garford Motor Truck Co., *Lima, Ohio.*

CLARK, WILLIAM T., factory manager, Fuller & Sons Mfg. Co., *Kalamazoo, Mich.*

CORNELIUS, P. W., tool designer, Midwest Engine Co., *Indianapolis.*

CORY, RUSSELL WILSON, layout and design draftsman, engineering office, Ordnance Department, 6545 Carnegie Avenue, *Cleveland.*

DERR, H. E., assistant chief engineer, International Harvester Co., *Chicago.*

DOOLITTLE, H. P., general patent attorney, International Harvester Co., *Chicago.*

DREHMANN, ALVIN, tool designer, U. S. Ball Bearing Mfg. Co., 4535 Palmer Street, *Chicago.*

DROMGOLD, FRANK A., draftsman, Bean Spray Pump Co., *San José, Cal.*

EARLE, JOHN H., engineer, Gary Motor Truck Co., *Gary, Ind.*

ELSTON, W. B., assistant chief engine engineer, Curtiss Aeroplane & Motor Corporation, *Garden City, N. Y.*

EVERETT, CHARLES J., vice-president, Everett Brothers, Inc., 320 Broadway, *New York City.*

EVES, A. P., chemist and metallurgist, International Harvester Co., *Chicago.*

FLY, ENOCH DORTCH, assistant engineer, Byron Engineering Works, *Louisville, Ky.*

FOSTER, H. F., Ingersoll-Rand Co., *Athens, Pa.*

FRALICK, L. J., assistant sales manager, Hydraulic Pressed Steel Co., *Cleveland.*

FRANCE, EDWARD A., district sales manager, Jones & Laughlin Steel Co., *Cleveland.*

FURUBAYASHI, USABURO, chief engineer, Tokyo Gas & Electric Engineering Co., 2254 Ipponmastu Oimachi, *Ebaragun, Tokyo, Japan.*

GAIDOS, ALONZO F., tool designer, Bean Spray Pump Co., *San José, Cal.*

GLICK, EDWARD G., chief tool designer, Imperial Brass Mfg. Co., *Chicago.*

GOCHNAUER, G. C., president, Belmont Motors Corporation, 29 North Second Street, *Harrisburg, Pa.*

GRAHAM, JAMES WILSON, designer, Hendee Mfg. Co., *Springfield, Mass.*

GRAVES, W. S., chief engineer, Shotwell Johnson Co., 712 Ontario Avenue, North, *Minneapolis.*

GUSTAVSON, ERICK H., mechanical engineer, Liberty Motor Car Co., *Detroit.*

HAIBE, RENO, research engineer, Kissel Motor Car Co., *Hartford, Wis.*

HALL, H. K., general manager, Cleveland Radiator Co., *Euclid, Ohio.*

HARBUTT, JOHN E., inventor of automobile accessories, 5122 West 30th Place, *Chicago.*

HAWKINS, P. E., engineer, Ohio Motor Vehicle Co., *Cleveland.*

HELMS, JOHN R., director of instruction, Petz Automotive School, Inc., *Philadelphia.*

HOERLE, NEWTON SWANK, manager of engineering department, Continental Motors Corporation, *Muskegon, Mich.*

HOLMGRAIN, E. O., chief draftsman, O. E. Szekely Co., *Moline, Ill.*

HOPKINS, WALLACE, purchasing and stock supervision, Laurence H. Pomeroy, *Cleveland.*

HOWER, HARRY S., director of research, Macbeth-Evans Glass Co., *Pittsburgh.*

HUGHES, RALPH C., engineer, Teetor Hartley Motor Corporation, *Hagerstown, Ind.*

JENSEN, MILTON O., engineer, Imperial Brass Mfg. Co., Chicago.

JOSLIN, FRED A., draftsman, Allison Experimental Co., Speedway, *Indianapolis.*

KEEFE, W. S., secretary and assistant manager, Gill Mfg. Co., 8300 South Chicago Avenue, *Chicago.*

KLINEDINST, L. M., manager tractor department, Timken Roller Bearing Co., *Canton, Ohio.*

KOEHNE, IRA CHASE, general manager and chief engineer, Preferred Motor Car Co., *Indianapolis.*

KRAMER, FRED T., draftsman, International Motor Co., West End Avenue and 64th Street, *New York City.*

LANDANE, GEORGE F., district manager, Duplex Engine Governor Co., *Brooklyn, N. Y.*

LEJEUNE, FRANK H., divisional engineer, Hayes Wheel Co., *Jackson, Mich.*

LEMON, ARTHUR, engineer, Excelsior Motor Mfg. & Supply Co., 3701 Cortland Street, *Chicago.*

LORING, ERNEST J., mechanical engineer, aircraft armament division, Ordnance Department, Frankford Arsenal, *Philadelphia.*

MCCAMPBELL, PAUL R., chief of development, G. & J. Tire Co., *Indianapolis.*

MCCREARY, HUBERT, instructor, Motor Transport Training School, *Baltimore.*

MCCREERY, CHESTER M., manager highway transportation development department, Goodyear Tire & Rubber Co., *Akron, Ohio.*

McKowen, Frank Leslie, assistant statistician, Victoria Falls & Transvaal Power Co., *Johannesburg, South Africa.*

MacCormack, J. G., assistant to director of training, Motor Transport Corps, 2314 Munitions Building, *Washington.*

MacDonald, Howard D., assistant manager, International Harvester Co., *Chicago.*

Maraniss, H. S., development engineer, Revere Rubber Co., *Providence, R. I.*

Miller, William O., draftsman, Holt Mfg. Co., *Stockton, Cal.*

Moritz, Julius Holland, designer, Garford Motor Truck Co., *Lima, Ohio.*

Neustadt, Frank, chief draftsman, Davis Sewing Machine Co., *Dayton, Ohio.*

Neuteboom, B. B., consulting engineer, Taylor & Neuteboom, *Detroit.*

Nichta, John J., assistant engineer, Aluminum Manufactures, Inc., *Cleveland.*

Orze, Stanley L., designer, J. I. Case Threshing Machine Co., *Racine, Wis.*

Perlov, Alexander Perel, efficiency engineer, Muncie Products Co., *Muncie, Ind.*

Pleasonton, F. R., general manager, Parish Mfg. Corporation, *Reading, Pa.*

Rapp, Arthur H., draftsman, Watson Products Corporation, *Canastota, N. Y.*

Reynolds, Capt. C. H., Air Service,, Langley Field, *Hampton, Va.*

Rice, Walter J., secretary and treasurer, Fox Motor Car Co., *Philadelphia.*

Risley, Capt. Dalton, Jr., Motor Transport Corps, *Camp Holabird, Md.*

Robertson, Charles J., mechanical engineer, Evans Stamping & Plating Co., *Taunton, Mass.*

Rodger, David William, sales manager, Muzzy-Lyon Co., *Detroit.*

Schneider, William G., electrical engineer, Maxwell Motor Co., 140 Calvert Avenue, *Detroit.*

Schuler, C. R., engineer, Midwest Engine Co., *Indianapolis.*

Scott, Nellie M., president and general manager, Bantam Ball Bearing Co., *Bantam, Conn.*

Sells, Osborne P., district engineer, Double Seal Ring Co., *New York City.*

Sexton, L. E., superintendent, Inland Rubber Co., *Chicago.*

Sheahan, Frank I., automobile design, Russel Motor Axle Co., *Detroit.*

Singleton, Frank C., automotive engineer, Standard Oil Co., 910 South Michigan Avenue, *Chicago.*

Small, R. C., works manager, Teetor Hartley Motor Corporation, *Hagerstown, Ind.*

Sperry, Leonard Boyd, chief engineer, International Harvester Co., *Chicago.*

Stockfleth, Berger, chief engineer, International Harvester Co., *Chicago.*

Swartwout, F. B., checker and layout draftsman, Supreme Motors Corporation, *Warren, Ohio.*

Tait, William O., Jr., experimental and test engineer, International Motor Co., *New York City.*

Triolo, Ray, draftsman, Holt Mfg. Co., 444 South Aurora Street, *Stockton, Cal.*

Vawter, H. L., chief engineer, Parenti Motors Corporation, *Buffalo.*

Walters, R. F., branch manager, Carr Fastener Co., *Detroit.*

Weeks, Roy F., mechanical engineer, Ford Motor Co., *Dearborn, Mich.*

Williams, Robert P., body engineer, Locomobile Co. of America, *Bridgeport, Conn.*

Young, Earle L., factory manager, Laminated Shim Co., Inc., *Hoboken, N. J.*

Young, Linwood H., owner, Linwood H. Young & Co., Beacon Street, *Boston.*

Zarucha, Robert M., master mechanic, Paragon Auto-Radiator Works, *Waterbury, Conn.*

Zimmerman, Oliver Brunner, engineer, International Harvester Co., *Chicago.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Aug. 10 and Sept. 10, 1920. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

Altenberg, Alfons (M) mechanical engineer, 424 Washington Court, *Sheboygan, Wis.*

Babel, Elmer H. (M) designer, Duplex Truck Co., Lansing, Mich., (mail) 129 West 28th Street, *Los Angeles, Cal.*

Bechman, W. O. (J) tractor works, International Harvester Co., *Chicago,* (mail) 3544 Thomas Street.

Blakemore, Thomas L. (M) aeronautical engineer, Army Balloon School, *Fort Omaha, Neb.*

Bowman, Christian C. (A) experimental engineer, Standard Motor Truck Co., *Detroit* (mail) 105 Beechwood Avenue.

Cook, Richard C. (A) owner, R. C. Cook Co., 2929 Wabash Avenue, *Chicago.*

Cooke, Dwight Irving (A) sales manager, Hercules Motor Mfg. Co., *Canton, Ohio* (mail) 1400 Cleveland Avenue Northwest.

Jacklin, H. M. (M) assistant chief engineer, Oneida Motor Truck Co., *Green Bay, Wis.,* (mail) 637 South Madison Street.

Kirby, Harley E. (A) sales engineer, Electric Storage Battery Co., 613 Marquette Building, *Chicago.*

Knapp, Karl W. (A) in charge of Pittsburgh district office, Cyclops Steel Co., Titusville, Pa., (mail) 429 Crandall Avenue, *Youngstown, Ohio.*

Larson, Louis V. (A) sales engineer, Dayton Engineering Laboratories Co., *Dayton, Ohio,* (mail) 1310 Epworth Avenue.

Lutey, William Thomas (M) body engineer, Lang Body Co., 3088 West 106th Street, *Cleveland.*

Moody, Col. Lucian B. (S M) Chief of Ordnance, *Washington.*

Newell, E. W. (J) engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., (mail) Bryn Mawr Road, *Wilkinsburgh, Pa.*

Olson, Gust, Jr. (M) general superintendent, Root & Van Dervoot Engineering Co., East Moline, Ill., (mail) 1831 14th Street, *Moline, Ill.*

Pearce, Frederick (M) checker and assistant chief draftsman, Packard Motor Car Co., *Detroit,* (mail) 498 Montclair Avenue.

Porter, R. E. (A) manager of equipment department, Gibson Co., *Indianapolis.*

Russell, R. S. (M) 828 Oak Street, *Kalamazoo, Mich.*

Shoemaker, Hervy B. (M) engineer, General Motors Corporation, Boyer-Campbell Building, *Detroit.*

Spahr, Dion G. (A) 425 South Brooks Street, *Sheridan, Wyo.*

Speer, James Kirker (J) designer, Pittsburgh Model Engine Co., *Pittsburgh,* (mail) 539 Rosedale Street.

Srigley, Wallace (J) Household Utilities Corporation, *Windsor, Ont., Canada* (mail) 511 Bruce Avenue.

Stebbins, Harry Young (F M) engineer, Goodyear Tire & Rubber Co., Detroit, (mail) Factory Perkun, *Warsaw, Poland.*

Taylor, Clarence L. (M) chief engineer, Morgan Engineering Co., *Alliance, Ohio,* (mail) 653 South Union Avenue.

Van Scoter, J. W. (J) heat-treating department, Curtiss Aeroplane & Motor Corporation, *Buffalo,* (mail) 635 Parkside Avenue.

Webb, W. L. (F M) engineer, Crossley Brothers Ltd., *Openshaw, Manchester, England.*